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UNIVERSITY OF ALBERTA

WOMEN BIOLOGY TEACHERS' NARRATIVES

by

SHARON FRANTZ-LUTZER

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF EDUCATION

DEPARTMENT OF SECONDARY EDUCATION

EDMONTON, ALBERTA

SPRING, 1990

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FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled WOMEN BIOLOGY TEACHERS' NARRATIVES submitted by SHARON FRANTZ-LUTZER in partial fulfilment of the requirements for the degree of MASTER OF EDUCATION in SECONDARY EDUCATION.

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Date: Feb 26, 1990

ABSTRACT

Womens' understandings of science educational praxis offer an alternative to traditional textual understandings of the nature of teaching science. Current sociocultural changes in sex-role stereotyping demand a concurrent examination of educational science practice, for underlying sexist biases.

This research study is a gender-related analysis of two female biology teachers' epistemological frameworks which govern their classroom functional paradigms. This study establishes a textual critique in which metaphors of gender politics in the narratives of two established science educators are no longer read as individual idiosyncrasies, but as relevant meanings in which science education is inextricably bound with traditionally masculine, western interpretive frameworks. Use of the narrative as a methodological tool of feminist inquiry impressions new meanings upon traditional conceptual schemes and reveals the two female voices within a phenomenological context. The analytical scheme that is employed attempts to reveal underlying patriarchal orderings of scientific knowledge and incorporates a post-modern feminist theoretical framework.

Underlying positivist and patriarchal orderings of scientific knowledge are found to be in conflict with the two women teachers' contextualist understandings, questioning the assumptions which traditional science education makes in its' theoretical substance and practice. Current contextual knowledge frameworks incorporating feminist epistemological perspectives are delineated in light of traditional educational models. Practically, in the science classroom, such retheorizing has implications for the scientific knowledge claims of both male and female students.

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CHAPTER 1

INTRODUCTION TO THE STUDY

Introduction

> When the woman who has a sister is a writer, she leaves us a special kind of legacy, for the sister-figure is so often present in writing, not, most likely, as she was, but as the writer felt her to be. She represents a specific interaction between female Self and female Other and the conversation that a writer has with her sister is often one that she could not have in her life. (Louise Bernikow, *Among Women*)[1]

In Lorna Irvine's *Sub/Version* (1986, p. 75), gender becomes a key issue for women writers. She uses Louise Bernikow's quote to invert traditional masculine narrative structures in order to tell women's stories. Irvine places in a central position, originally silenced or peripheral female roles. Her themes concentrate on, "female silence as it occasions male speech"; it is an expression of the failure of women to bond with each other. She extends her comments to the gaps and secrecy in women's narratives, the suppressed speech - metaphorically, the haunting images in the mirror which the female 'self' sees in female 'other'.[2]

In *Feminist Scholarship: Kindling in the Groves of Academe*, Ellen Dubois, et al. (1987, p. 18) suggests that once academic woman began to explore how critical

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[1] The epigraph is from Louise Bernikow's *Among Women* (New York: Harper & Row, 1980), p. 103. It is quoted in Lorna Irvine's *Sub/Version*. Toronto: ECW Press, 1986, p. 73.

[2] Chapter 2 will investigate feminist post-modernism, particularly French literary criticism as expressed in Homans, M. (1980) and Irigaray, L. (1985) and Irvine (1986).

literary theory and philosophy could be the locus for feminist inquiry, i.e., could be employed in the investigation of women's lives, then deeply hidden male biases in the methodology and substance of research inquiry could be revealed. Indeed, if the questions guiding research are designed so that only male activities can provide the answers, then it is difficult if not impossible to obtain an accurate woman's interpretive framework. Dubois, et al. goes so far as to suggest that by challenging biased assumptions, new questions and answers arise; and that they in turn, create the conditions for a radical restructuring of research frameworks so that women are not pushed to the margins of academic inquiry.[3]

In, "*The Metaphor in Science and in the Science Classroom*" (1988), Paul Muscari observes that the unconventional semantics of metaphorical language execute certain functions which literal language is unable to perform: "by dislodging us from fixed conceptual schemes, metaphors are primed for helping us place our impressions into newly fashioned units of meaning" (p. 423). Metaphorically, then both Irvine and Dubois, et al. speak to the question of, "which interpretive frameworks do our research 'narratives' represent?" This is a significant question, and in exploring research narratives in science education, the researcher wishes to inquire about the nature of knowledge claims in this discipline. In teaching science

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[3] Ellen Dubois, Gail P. Kelly, Elizabeth L. Kennedy, Carolyn W. Korsmeyer, Lillian S. Robinson. *Feminist Scholarship: Kindling in the Groves of Academe*. Univ. of Illinois Press, Urbana, 1987, p. 18. The authors state that the importance of feminist critiques reach beyond the identification of male bias, to suggest directions for subsequent research. Critical examination of the fundamental assumptions of traditional scholarship has prepared the way for studies that yield a fresh, even revolutionary understanding of women's being.

to our students, what constitutes the 'text'? Metaphorically, which 'texts' are researched and what underlying assumptions exist? Are our research stories extensions of men's 'texts'? Where is the female voice - her authenticity - her authority?

This research study will establish a textual critique in which metaphors of gender politics in the narratives of established science educators are no longer read as individual idiosyncrasies, but as relevant meanings in which science education is inextricably bound with traditionally masculine interpretive frameworks.

Purpose of the Study: Women Biology Teachers' Narratives

If one wishes to participate in and elucidate the ongoing process that makes up women's interpretive frameworks, one needs to insist upon the importance of women as interpreters of text. This requires an honest and thorough analysis of the way in which gender shapes those interpretations. Feminist critique, feminist theory and feminist methodology play a crucial role in the process by which women's experience is articulated.

The Narrative

Irvine (1986) points out that writing women's narratives is a major task of feminist inquiry. The narrative centralizes the female voice; metaphorically, 'ways of seeing', will thus be altered.

Pagano (1988, p. 322) in *Teaching Women*, suggests that teaching is considered to be, "the enactment of narrative" and questions the authority with which woman have been able to command compliance, "with one's [own] acts of

signification." Pagano raises the interesting question, "was there ever a life more riddled with self-doubt than that of a woman teacher?" (p. 338). Pagano suggests that what she doubts are the dominant forms of knowledge, privileged ways of knowing; hence, the female teacher's narrative has been stripped of authority. How can she know what she has never been privileged to know?

Dubois et al. (1987, p. 29) suggest that through the narrative structure, through investigating women's lives, the illusion of sexual neutrality to particular women's issues is dispelled. Dubois et al. goes so far as to suggest that scholarship can then address the assumptions of the discipline itself to reveal male's biases hidden in the methods and substance of the academic discipline's theory.

In science teaching, we can question the separation of 'educational knowing' from 'knowing' acquired through women's lived experience. If we can appreciate how women teachers in science come to accept certain meanings, through their narratives, then we can question the assumptions which science education makes in its theoretical substance and in its research methodology.

The first goal is to accurately represent women's stories, to impression new units of meaning upon fixed conceptual schemes and frameworks. In examining the text - science education - is it possible to re-read science teacher's narratives and to shift the focus from central to peripheral understandings; that is metaphorically, to shift epistemological awareness from the central to the marginal.

In this study, the researcher will examine the 'texts' of women science teachers, as representative of these women's narratives on science teaching.

Educational Rationale

A reformulation of the use of the term paradigm[4], in research on science teaching can steer us on a path towards more critical thinking. This reformulation addresses the problem of redirecting research on teaching, from an emphasis on how science classrooms function, to one on why they function in particular ways. Teachers functioning in a particular classroom paradigm offer a model or exemplar for their colleagues and students. It is useful to examine the epistemological frameworks or knowledge structures, in the functional paradigms of science teachers and analyse the conceptual meanings which speak to the intellectual climate in the science classroom as these meanings influence students' knowledge claims.

In analysing these knowledge structures, underlying patriarchal orderings of scientific knowledge might be revealed. This provides a deeper understanding of how female science teachers go about their professional practice; how they conceptualize the nature of the science they are teaching, and how they interpret such knowledge in the classroom. An educational research study of this nature allows science educators 'to see' and 'to think' more clearly and deeply, about the contextual nature of educational science practice.

In order for our science educational choices and curriculum policies to be theoretically critical, particularly with the impending changes in the new junior high and senior high school science curricula, at hand - the delineation and examination

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[4] Paradigm - a scientific exemplar embodying experimental results and procedures; patterns of theoretical interpretation and methodological orientation. An application of this term from its theoretic context to distinguishing it in relation to classroom functioning, has been adapted in the form of the functional paradigm. See Chapter 3.

of current contextual knowledge frameworks of science teachers, in light of alternate epistemological criteria, is judicious.

Metaphorically then, women's stories of science educational practice can alter traditional textual understandings of the nature of teaching science. The time is right in curriculum theorizing for delineating, and analyzing current contextual knowledge frameworks of science teachers, in light of feminist epistemological perspectives. Practically, in the science classroom, such retheorizing has implications for the scientific knowledge claims of both male and female students.

A Statement of the Research Problem

This study attempts to **provide a gender-related analysis of two women biology teacher's epistemological frameworks, which govern their classroom functional paradigms.** A narrative approach is used methodologically to investigate these two women science teachers interpretive frameworks.

What follows is a textual critique in which metaphors of gender politics in the narratives of women science educators are no longer read as individual idiosyncrasies, but as relevant meanings in which science teaching is inextricably bound with specifically masculine and Western ideologies. Within a feminist framework, a critique becomes significant when it empowers women - by acknowledging the power struggles that go on, rather than by ignoring them. The researcher will attempt to analyse the knowledge structures of two women biology teachers for underlying patriarchal orderings of scientific knowledge; to analyse how these teachers conceptualize the nature of the science they are teaching, and how they interpret such knowledge in their classrooms.

Metaphorically, if our research stories are extensions of men's texts, then this text hopes to invert traditional masculine narrative structures and place the female voice in a central position, with authenticity and with authority.

Methodological Approach to the Study

Methodologically, the textual critique to be sketched out is premised upon the nature and complementarity of qualitative research in and to feminist inquiry. Theoretically, it becomes important to articulate the nature of this paradigmatic inquiry and its relation to the questions which are under investigation.

Fields of scholarly work offer a staggering variety of theoretic bases for the development of research perspectives and formulations in science education. Selecting a basis for developing theoretical perspectives appropriate to this study is guided by a demonstrable linkage to issues of everyday women's science educational practice. The objective of the study is to provide description and understanding; not undue extrapolation and/or judgemental bias. However, 'we/women's' bias forms the gender-related epistemological framework from which interpretations will emerge. Ontologically then, there are basic assumptions, limitations and delimitations in this particular study.

Ontological Dimensions and Generalizability

Gender is one of the fundamental categories according to which we organize our experience of ourselves and others. If we are to explore alternatives to methods, assumptions, and goals which have served to preserve men's ways of 'knowing' and

hence male authority, then we must engage in a 'reading of the text' through a feminist lens.

The premise that personal knowledge and social structure are related dialectically, stems from theories in the sociology of knowledge, hermeneutics, sociolinguistics, and feminist theory. Feminist critiques and feminist theory play a crucial role in analysing the processes by which women's knowledge is articulated in the social context. In understanding women teacher's shared meanings, we need to engage in a hermeneutic understanding of text. The meaning the text has for the researcher and the meaning that the researcher brings to the text can only be understood if we accept that gender shapes our interpretations.

Traditional epistemologies have dichotomized the social, political context from the 'knowing' experience. According to Sandra Harding[5], traditionally, "to be a 'knower' is thought by nature, to be capable of reason, of dispassionate, impartial judgement, and of objective analyses." This separates one's subjective desires for how the world should be from one's objective description of explanation of the world. Traditional epistemologies equate the 'knower' with objectivist traits which emphasize control. To be a woman in patriarchal tradition, is thought to preclude possession of such traits. Where is the female voice - her authenticity - her authority?

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[5] Sandra Harding. *"Ascetic Intellectual Opportunities: Reply to Alison Wylie* in *Science, Morality and Feminist Theory*. Ed. by M. Hanen & K. Nielsen, University of Calgary Press, Calgary, 1987, p. 77.

This study will incorporate ontological dimensions into 'science teaching', in that we cannot separate 'educational knowing' from 'knowing' acquired through 'we/women's' lived experiences. To what extent are 'we/women's' experiences fruitful groundings for research problems and for knowledge claims? In Chapters 5 and 6 the researcher will attempt to provide thoughtful reflection on this question.

The researcher recognizes the delimitations of the power of one's own analysis in making generalizable knowledge claims. Hence, this study is an attempt to hear two women teacher's 'ways of knowing' from each woman's point of view. The shared meaning the research brings to [her] text reflects the researcher's own shared 'knowing', as a woman teacher, hence the researcher will often employ 'we/women' as an expression of this shared knowledge. The nature of these ontological dimensions which are inherently part of a feminist inquiry, necessitates a qualitative research approach.

Theoretical Science Educational Research Paradigms

Scientific educational inquiry displays an ethical dimension, in that it makes reference to an authoritative election concerning how a phenomenon ought to be understood. Crucial to this study is the philosophical task of assessing and interpreting whether the ideal of objectivity in research, which has been fundamental to science, is indeed beyond question.

From a philosophical stance, Israel Scheffler (1965, 1967)[6] stresses the importance of the development, transmission and analysis of knowledge as fundamental tasks of education. Scheffler's philosophical task in the examination of the epistemological bases of objectivism, includes an analysis of alternative epistemological criteria. A philosophical discussion of Scheffler's position is included in Chapter 3. Relevant to this discussion, is Scheffler's exploration of science educational research as an epistemological exploration. As a starting point, Scheffler's research engages us in epistemological questions of difference in quantitative and qualitative research in science education.

Douglas Roberts continues this exploration in *The Place of Qualitative Research in Science Education* (1982). Roberts points out that the differing sets of metaphysical presuppositions that give rise to the two approaches: quantitative and qualitative, are explained by using Stephen Pepper's model of 'world hypotheses'.[7]

Roberts suggests that the world hypotheses of 'formism' and 'mechanism' give rise to a metaphysical preoccupation with relationships to norm, quantified locations in time and space, and determinism. These are root metaphors for quantitative procedures for getting at truth. Alternatively, the world hypotheses of 'contextualism' and 'organicism' employ root metaphors which integrate quality,

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[6] A more thorough discussion of Israel Scheffler's, *Conditions of Knowledge* (1965), *Science and Subjectivity* (1967) is found in Chapter 3.

[7] For further discussion of Pepper's model of 'world hypotheses' see Stephen Pepper's, *World Hypotheses: A Study in Evidence*. Berkeley, CA: University of California Press, 1942.

context, contradictions and holistic explanations into a framework for qualitative procedures for getting at truth. Given the emergence of qualitative research styles, Roberts explores the implications for the development of science education as a total enterprise:

> Contextualism is a system of thought that focuses on the event in its context. We have no adequate knowledge of an event, according to this world hypothesis, until we know the context in which it occurs; it is not enough to know the form of the event, or even the mechanism that is, metaphysically speaking, responsible for it. In fact, both kinds of knowledge might be totally irrelevant. Whenever anyone does a good case study in science education, scratch the surface and you will almost surely find contextualist thinking. A good case study based on contextualist thought requires qualitative data . . . (1982, p. 279)

A contextualist researcher acknowledges alternative philosophies and their features, in context, but there is no drive to choose one over the other. Roberts goes on to suggest that there is nothing mystical about contextualist thinking, for the evidence condition is ever present. Rather than repeated checking of the same phenomena, as in formism/mechanism (multiplicative corroboration), validity relies on varied checking of different sources and phenomena, over time.

H. Svi Shapiro (1983), recognizes that more graduate training in research methods should include a recognition of qualitative educational scholarship. He states further:

> among these . . . [qualitative studies] . . . is a rejection of quantification as a necessary ingredient of research, a more critical attitude towards the certainties of the adequacy of empirical evidence, recognition of the pervasiveness of subjectivity or consciousness in the accumulation of data, and attention to the existential moment and concreteness of experience rather than the abstracted evidence of nomothetically-oriented inquiry (p. 127).

In this sense, Shapiro explains that the struggle to create a new paradigm (or paradigms) for educational inquiry must be seen as centered on issues of methodological freedom and epistemological diversity. He states that the sociological roots of the new forms of inquiry make clear that what is involved is not merely a matter of abstract, theoretical dispute, but one that inextricably involves issues of political control, cultural hegemony and the defining of social reality.[8] Shapiro would suggest that questions about educational inquiry have value dimensions, in that they assume choices as to the relevant realms of expertise or control that a researcher may ascribe to.

In *Improving Educational Research Through the Development of Educational Paradigms* (1983), Tuthill and Ashton reflect upon the epistemological disputes in educational research. In an attempt to differentiate between the development of different educational paradigms of research, they cite a dualist philosophy between theory/practice as the source of conflict. In establishing research goals, researchers are caught in the dualism of a descriptive attempt to develop theory or a pragmatic attempt to improve practice. For example, Kerlinger (1977) promotes theory development as the aim of educational research and Scriven (1980), advocates improved practice as the goal of educational research.

Philosophically, this conflict is embedded in a realist/idealist dualism. Tuthill and Ashton believe that what is to count as knowledge or to be considered true, is a matter of agreement within a socially and historically-bound context. They

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[8] Shapiro incorporates a hermeneutical approach in, "*Educational Research, Social Change and the Challenge to Methodology: A Study in the Sociology of Knowledge*" found in *Phenomenology and Pedagogy*, Vol. 1: No. 2, 1983, p. 138.

incorporate a Kuhnian model of paradigmatic epistemology to encourage educational theoretical researchers and practitioners to work together, as members of the same paradigmatic communities, solving the same paradigmatic puzzles. When conflicts arise, new paradigms of inquiry emerge, and a recognition of pluralism in paradigmatic educational inquiry is encouraged.

Jacknicke and Rowell (1987) support this and propose that our world view determines how we perceive educational research. Alternative paradigms of how we view the world are outlined and related to three different inquiry orientations. The nature of educational research as viewed from these different orientations is described.

The authors have premised their thesis on Jurgen Habermas[9] understanding that the procedures and goals of normal science are inseparable from concerns with political control and social domination. Habermas' taxonomic analysis of the logical structure of what he identifies as the three basic forms of 'knowing', provides an interesting framework for examination orientations in research inquiry. Habermas states that traditionally, meaning has come from monologic verification of facts rather than a dialogic interpretation. He states that methodology in science has become linear rather than a circular reciprocal relationship between the parts and the whole. Habermas develops a taxonomic structure which allows us to differentiate those types of scientific inquiries according to their underlying structures of interest. Using a tri-paradigmatic framework, he suggests that the three

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[9] For further discussion read Habermas, J. (1971). *Knowledge and Human Interests*. Boston: Beacon Press.

types of 'knowing' are not neutral but presuppose a distinct 'cognitive' orientation to the world and aim at different goals. Each pictures the world in its own unique fashion because of a fundamental interest.

In this framework, science can be a form of 'technical knowing' that cognitively and practically relates humans to their natural world. Science can be a form of 'situational knowing' which relates humans to their cultural and social world as well. Or science can be a form of 'critical knowing' which through self-reflection, relates humans to themselves and their world.

Ted Aoki (1978) has taken Habermas' analysis of these three fundamental cognitive human interests that are the grounds for knowledge and expanded these into the area of educational curriculum theory. Aoki categorizes three inquiry orientations based on Habermas' paradigmatic framework. The first category involves an 'empirical-analytic' orientation which seeks technical and explanatory knowledge. The second category is based upon a 'situational-interpretive' perspective, in which meaning is given within a historical context. This category is also more existential in nature. The third orientation seeks to uncover underlying interests and assumptions in a 'critically-reflective' fashion. Social implications are explored and therefore social action becomes a very important part of this mode of inquiry.

Jacknicke and Rowell (1987) identify major structural perspectives, related to educational research inquiry, shaped by these dominant cognitive interests. This research study will expand on these, because these orientations to educational

research become theoretically important for providing a rationale for engaging in a qualitative research inquiry.

Jacknicke and Rowell's first educational research orientation leads one to approach the world objectively, with the primary interest of controlling events and objects. Man/woman is dichotomized from the environment and acts on the world, transforming it and explaining events with certainty and predictability. The critical interest is 'control'. Within this orientation there is a great concern for the validity and reliability of the knowledge gained, therefore statistical analyses and empirical evidence are of primary importance. This approach leads to the separation of theory and practice. Once a researcher has achieved an acceptable level of 'fit' between the data observed and the categories of theory devised, the problem then becomes a technical one - to work out an efficient method of applying the theory to obtain the ideal state.

The second orientation does not view man/woman as separate from his/her world. Communication between humans generates interpretive, inter-subjective, or trans-cultural knowledge consisting of meanings people give to their situations. In the situational paradigm, there exists multiple ways of knowing. Subjective experience of life becomes the focus of attention. The major focus of research is to provide meaningful description and interpretation of events and phenomena. Jacknicke and Rowell suggest that rather than developing *a priori* theoretical statements for which validation is sought, concepts and interpretive frameworks are only suggested by the researcher, and these are tentative and subject to change as

more powerful concepts or themes emerge. The researcher must also enter into inter-subjective dialogue with the people in the research situation.

In the final paradigm, a critically reflective inquiry views man/woman as integral components of their own world, both acting upon and being influenced by the environment. The critical orientation is interested in probing for underlying bases in order to reveal tacitly held intentions and assumptions. A reciprocity exists between reflective thought and action. The critical researcher seeks to uncover underlying assumptions involved in answering questions, such as: what knowledge is of most worth; who will decide what knowledge is acceptable; whose interests are being served.

Jacknicke and Rowell suggest that concerns relating epistemology, power relationships, root metaphors and politics of schooling need to be analyzed so that participants have a clearer view of their situation. They acknowledge that what is required in inquiry is an awareness of the multiplicity of views and orientations, along with differing approaches to educational research questions. They encourage tolerance of alternate perspectives, viewing the tension between alternate paradigms of inquiry in a positive way, as a force which will build bridges and bring about deeper dialogue, rather than form walls.

Summary: A Feminist Framework

Scheffler encourages the researcher to use philosophy as a lens - to examine meaning and epistemology to see what it can contribute to science theorizing and practice. Roberts alerts the researcher to the complexity of belief systems, insofar as a world view represents an epistemology, which governs the researcher's aims and

goals. Roberts' recognition of alternate research approaches in relation to education, is paramount, in adopting an epistemologically critical approach to research in science teaching.

Shapiro's work frames research inquiry within the 'sociology of knowledge' and further defines the nature of subjectivity as a factor in the definition of a socially constructed reality; hence subjectivity is a factor in educational research into science teaching.

Tuthill and Ashton recognize the plurality of paradigmatic educational inquiries and encourage the researcher to pursue knowledge claims within a Kuhnian epistemological model - 'what counts as knowledge', is a matter of socially and historically-bound context.

Jacknicke and Rowell reveal essential categories of thought through which meaning is made of teaching and learning conceptual processes. They acknowledge research orientations which encourage tolerance of alternate epistemological perspectives.

In keeping with a qualitative research orientation, the analytical scheme that is employed to analyse and interpret women teacher's conceptions of biology as they relate it to scientific knowledge, recognizes the significance of situational - interpretive and critically reflected studies, as described by Jacknicke and Rowell (1987).

The feminist critique recognizes that meaningful description and interpretation of events and phenomena are the 'texts' by which women's teaching stories are revealed. The narrative format which has been described according to

Irvine (1986), Pagano (1988) and Dubois, et al. (1987), helps to reveal the authenticity of the female voice. Her authority is centralized through the narrative form.

At the same time, a critical orientation is engaged in probing for underlying patriarchal bases in order to reveal tacitly held intentions and assumptions. In order to uncover what knowledge is legitimated by the teacher; to uncover the interests being served, a feminist analytical critique or schema is employed which reveals women's experiences in the 'teaching of science', as authentic and different from men's experiences. Her understandings of knowledge as 'legitimate' knowledge, is questioned through an inversion of male narrative structures, and tacitly held assumptions about the nature of this knowledge, are revealed. Chapter 4 outlines the premises of this feminist analytical schema.

At this point in the research study, it is important to articulate the conceptual framework for the research. This framework is divided into two parts. The first part, in Chapter 2, engages the reader in a philosophical discussion of knowledge and of knowledge formation in science, from alternative epistemological and ontological perspectives. The second part of the conceptual framework, in Chapter 3, questions the separation of educational 'knowing' from 'knowing' acquired through we/women's lived experience.

CHAPTER 2

CONCEPTUAL FRAMEWORK OF THE STUDY (PART I): INTEGRATING THE SCIENCE QUESTION INTO FEMINISM

Introduction

> No myth is more familiar than that of Pandora, none perhaps has been so completely misunderstood. Pandora is the first woman, the beautiful mischief; she opens a forbidden box, out comes every evil that flesh is heir to; hope only remains. The box of Pandora is proverbial and that is the more remarkable as she never had a box at all. (Jane Harrison, *"Pandora's Box"*)[1]

In Lorna Irvine's *Sub/Version* (1986), the myth of Pandora serves the author well. As Irvine explains, represented as the first woman, Pandora was, like Eve, created by man to explain the presence of worldly evil. By opening the forbidden box, Pandora alters the face of the earth. She is also a sexual temptress who distracts man from duty and honour. The myth condenses culture and psychology, specifically around sexuality. For girls to grow up with the conviction of innate and uncontrollable perversity reflects ideological conditioning. Irvine questions the ideas and laws within which we/women must exist and subverts the established ideology; searching for theoretical determinants which advance new textual understandings of the organization of gender.

This chapter outlines the conceptual framework for the study. Although an examination of alternate textual understandings of the organization of gender may

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[1] The epigraph is from Jane Harrison's, *"Pandora's Box," Journal of Hellenic Studies*, 20, 1900, p. 99. It is quoted in Lorna Irvine's *Sub/Version*. Toronto: ECW Press, 1986, p. 111.

seem more in keeping with critical literary theory, or post-modern psychoanalytic theory, the researcher intends to estabish a textual criticism, in which metaphors of gender politics in the writings of established educators, are no longer read as individual idiosyncrasies, but as relevant meanings in which science is inextricably connected with specifically masculine and Western ideologies. By outlining this conceptual framework, the backing for the study is clarified and the particular predispositions of the researcher are revealed to the reader.

The word *black box* is used by cyberneticians whenever a piece of machinery or a set of commands is too complex. In its place they draw a little box about which they need to know nothing but its input and output. Perhaps opening Pandora's black box and examining some of the disquieting complexities which lie therein; offering alternative understandings to those which substantiate masculine-biased output, would be helpful in articulating feminist ideologies which can influence the epistemological scientific and educational choices we make.

A Conceptual Framework: The Science Question in Feminism

Sandra Harding in *The Science Question in Feminism* (1986), formulates new questions about the nature of our understandings in science. Her lucid description, critique, and synthesis of contradictory tendencies among the feminist epistemological discourses remains a leading scholarly endeavour, one the researcher has chosen to draw a theoretical framework from, to investigate and critique the epistemological foundations of science educator's teachings in the classroom. Harding recognizes that feminists in other fields of inquiry have begun to formulate challenges to the conceptual frameworks of their disciplines and have re-theorized

the understandings that their particular subject matters could provide. This is important insofar as putting the voice of feminist science criticism within an interdisciplinary context: a context within which women's perspective on gender symbolism, gender structure, and individual gender[2] remains central. Harding suggests that anthropology, sociology, history, and literary criticism, indeed influence epistemological questions raised in science and that we/women are engaging in a "politics of knowledge-seeking," which can show us the conditions necessary to bring equity in control/power from the "haves" to the "have-nots".[3]

> What kind of understanding of science would we have if we began not with the categories we now use to grasp its inequities, misuses, falsities and obscurities but with those of the biologist protagonist imaged by Marge Piercy in *Woman on the Edge of Time*?, who can shift her/his sex at will and who lives in a culture that does not institutionalize (i.e. does not have) gender? . . . perhaps we should turn to our novelists and poets for a better intuitive grasp of the theory we need.[4]

So says Harding. But does her eclectic approach complicate an already complicated issue. Ironically, Harding's formulations of new questions and issues to be

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[2] Sandra Harding. *The Science Question in Feminism*. Ithaca: Cornell University Press, 1986, p. 18. Harding suggests that gendered social life is produced through three distinct processes: a) *gender symbolism*; assigning dualistic gender metaphors to varied perceived dichotomies that rarely have anything to do with sex differences, b) *gender structure*; the consequence of appealing to these gender dualisms to organize social activity; of dividing necessary social activities between different groups of humans, c) *individual gender*; a form of socially constructed individual identity only imperfectly correlated with either the 'reality' or the perception of sex differences.

[3] Sandra Harding, p. 20. Harding suggests, "that we may be so preoccupied with responding to the sins of contemporary science that we have not yet given adequate attention to envisioning truly emanicipatory knowledge-seeking."

[4] Sandra Harding, p. 20. Harding draws from Marge Piercy's, *Woman On the Edge of Time*. New York: Fawcett, 1981.

addressed, in science, as well as her sophisticated and complicated critiques, serve to clarify many of the contradictory tendencies among the feminist epistemological discourses. Harding recognizes that these contradictions and problems do not originate in the feminist discourses, but reflect the disarray in mainstream epistemologies and philosophies of science since the mid-1960s. She asserts that the feminist entrance into these disputes should be seen as, "making significant contributions to clarifying the nature and implications of paradoxical tendencies in contemporary intellectual and social life.[5]

Harding discusses several lines of feminist inquiry which have made contributions to the overall question of women in science. These lines of inquiry are critiqued and synthesized into three basic epistemological frameworks. Collectively, these frameworks have made it possible for we/women to formulate new questions about science. It is a virtue of these critiques that they quickly bring our attention to the socially damaging incoherences in nonfeminist discourses. At the theoretical level, it allows we/women to reformulate the question: while the first epistemological framework primarily asks how women can be more equitably treated within and by science the last two ask how a science, apparently so deeply involved in distinctively masculine projects, can possibly be used for emancipatory ends. Harding asks us to move from the women question in science to the more radical science question in feminism:

> Where the woman question critiques still conceptualize the scientific enterprise we have as redeemable, as reformable, the science question

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[5] Sandra Harding, p. 28. Clearly there are contradictory tendencies amongst the feminist epistemological discourses. Harding outlines each with its own set of problems, in a lucid critique.

> critiques appear skeptical that we can locate anything morally and politically worth redeeming or reforming in the scientific world view, its underlying epistemology, or the practices these legitimate.[6]

As a conceptual framework from which to develop this thesis, that science educator's scientific knowledge structures which govern their classroom teachings are indeed gender-related and deeply entrenched in masculine, and Western constructs, the researcher will discuss Harding's epistemological frameworks which govern the gender/science inquiry since Harding synthesizes current lines of feminist thought very clearly. Harding leaves enough flexibility within her own arguments to belie structuralism or offensive categorization and sometimes broad categories can be useful to clarify philosophical lines of thought, as they tend to be convoluted. An important component of this discussion is to present some of the new philosophies of science to the reader; that is, to examine knowledge and knowledge formation in science, from alternative epistemological and ontological perspectives.

Feminist Empiricism

The idea of theory-independent facts, constituting the incorrigible foundation of knowledge identifies a positivist theme, originating with Francis Bacon and the British empiricists in the early 1600s. The evolution of logical positivism, influential in the "*Vienna Circle*" of the 1920s, is characterized by a reductionist view of scientific theory whereby all scientific knowledge can be reduced to empirical truths, which serve as a form of criterion of meaningfulness to demarcate scientific from

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[6] Sandra Harding, p. 29. This thematically underscores the title and content of Harding's book.

non-scientific discourse.[7] This means that there is a strict commitment to a fact/value dichotomy; typically a "scientistic" disavowal of any knowledge apart from science, explains its aversion to metaphysics.

Positivist themes in scientific theory become an extremely influential intellectual trend, forming until very recently, the generally accepted view of science. This empiricist epistemology posits an historicist[8] conception of the inevitability of scientifically mediated progress; thus, in biology, the tendency to view a progression toward an even more complete knowledge of nature through elaborated techniques such as controlled experimentation, the use of scientific quantitative and statistical techniques, the replication of findings, and the submission of results to the collective criticism of the scientific community. Science is presented as an "objective" force above and beyond society. It is seen as a monolithic power, claiming to be the arbiter of truth. At a personal level, the claim of "objectivity" divorces scientific knowledge from any emotional or social commitment.

Within this epistemological framework, Harding (1986) categorizes a feminist line of inquiry, which adheres to these existing methodological norms of scientific inquiry. "Feminist empiricism" argues that sexism is a social bias correctable by

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[7] Bynum, Browne and Porter (eds.). *Dictionary of the History of Science*. Princeton: Princeton University Press, 1984, pp. 334, 381. A detailed description of positivism appears in this dictionary. Karl Popper is typically associated with substituting "falsifiability" as a criterion of demarcation. The idea that science should be the model for all branches of knowledge still exists today.

[8] Bynum, Brown and Porter, p. 189. "Historicism is the idea of the radical importance of history as an explanatory principle. It has had various interpretations over the course of history, but Karl Popper's interpretation is the usage now received: historicism (differentiated from historism; past definitions) reflects the doctrine that the social sciences can predict long-term historical trends."

providing opportunities for an enlarged perspective, with more women scientists who are more likely than men to notice androcentric bias.

For example, in Zelda Isaacson's (1987) article, *Mathematics Has No Gender*, the author endorses a report by the Joint Mathematical Education Committee of the Royal Society and the Institute of Mathematics and its Applications, the Royal Society, London, 1986. This report states that there is no "persuasive evidence" that women's under-achievement and under-representation in mathematics can be accounted for adequately by innate or genetic disability, and that the "evidence - statistical, anecdotal and attitudinal" points to a range of educational and social factors that may be "causative and influential." Isaacson agrees that the statistics which reflect the larger number of men graduating and taking up professional careers in mathematics, point to a pressing need to change the social and educational climate in which girls learn math. She supports the report's recommendations to include women role models; ensure that teaching materials and examination questions are non-sexist; implement equal opportunity policies at all levels, and encourage girls to develop problem-solving skills and be "adventurous" from an early age.

The numbers of women in science, the inclusion of women science researchers in major journal publications, the inadequacy of the educational system to prepare women for professions involving empirical thinking, and the lack of female role models, are acknowledged as important lines of inquiry for feminist

empiricists (Yalow, R., 1978; Whelan, 1983; Butler Kahle, J., 1983, 1985, 1987; and Rom, Y., 1987).[9]

Harding (1986) argues that an ambivalence appears when feminists appeal to scientific "facts" to refute sexist claims to provide scientific "facts", while simultaneously denying possibility of perceiving any reality apart from socially constructed language and belief systems:

> How can we appeal to our own scientific research in support of alternative explanations of the natural and social world that are "less false" or "closer to the truth," and at the same time question the grounds for taking scientific facts and their explanations to be the reasonable end of justificatory arguments? (1986, p. 138)

She also suggests that a key origin of androcentric bias can be found in the selection of problems for inquiry and the definition of what is problematic in scientific phenomena. Empiricism justifies the context in which hypothesis and interpretation of evidence take place within the rational pursuit of "absolute truth", but does not acknowledge the context of discovery and social phenomena whereby problems are identified and defined. Thus a powerful source of social bias appears completely ignored through the control of scientistic methodological norms. Harding states:

> . . . it appears that following the norms of inquiry is exactly what often results in androcentric results. Thus, feminist attempts to reform what is perceived as [sexist] science brings to our attention deep logical incoherences and what, paradoxically, we can call empirical inadequacies in empiricist epistemologies (1986, p. 26).

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[9] Much of this research has been paramount in exposing androcentric interests in science. Although a philosophical argument ensues refuting empiricist inadequacies in theory, it is nevertheless recommended that the reader understand the significance of this worthwhile resource of literature.

The belief that the social identity of the observer can be an important variable in the potential objectivity of research challenges the assumptions upon which feminist empiricism are based. In addition, placing science with an ahistorical framework fails to recognize the incoherences in theory and actually distorts the actual processes through which explanations of natural phenomena have been achieved. In *The Structure of Scientific Revolutions*, Kuhn (1970) directs our attention to the social processes through which inquiry proceeds in science.

The Alternative Philosophies of Science

Kuhnian philosophy (1962, 1970) relates the accomplishments of individual scientists to an internalist scientific cultural context or paradigm[10] in which scientists' research is carried out; hence, science's tradition, and received culture are foci for empirical curiosity.

One of the interesting insights which Kuhn's model develops, is not so much that scientists choose to base their research on paradigms, as that science must proceed on the basis of paradigms. Kuhn expects to find this "normal science" interrupted by revolutionary episodes which are vital to the evolution of scientific culture. The resulting discontinuity in scientific practice, language, and perception, is the basis for the evaluation of knowledge-claims in the new paradigm. Paradigms are formally incommensurable; this is an important feature of Kuhn's model, since no rational discourse can exist between paradigms. Nor is their any clear sense in

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[10] Thomas S. Kuhn. *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press, 1970. Kuhn includes in this edition, a post script which clarifies some of the misunderstandings from the original edition and modifies, in semantic form, the term "paradigm" or "exemplar", replacing it with "disciplinary matrix".

which a later paradigm and conceptual fabric is ontologically superior to an earlier one. Kuhn suggests that the scientist within a new paradigm, sees differently from the way he had seen before.

Kuhn's study set off a veritable resurgence of sociological, historical and anthropological studies of science, creating what Harding (1986, p. 198) calls, "a fruitful disarray of philosophical thinking about the history and present practices of the sciences." However, Harding goes on to explain that gender is no more an analytical tool for the post-Kuhnian thinkers than it was for the traditional observers of science: "the usual array of androcentric gaps and distortions appears in these [recent] studies, too."

Kuhn's discussion of internalist dependencies on tradition and precedence, within the scientific disciplines (Toulmin, S. 1972; Feyerabend, 1975 offers a somewhat more anarchistic account), was followed by concomitant accounts of externalist institutional change, suggesting a reciprocity between the search for scientific knowledge and the context of societal values. A number of social philosophers attempted pertinent synthesis (Foucault, M., 1970; Greene, J., 1971; Young, R. & Teich, M., 1973; Shapin, S., 1979; and Barnes, B., 1982).

Due to the philosophical complexities of these works, a few of the crucial issues in the new philosophies of science, will be highlighted:[11]

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[11] Positivistic interpretations have been confronted with radical contextualist, sociological and relativist attacks. These attacks have had several different points of departure and the researcher has drawn from D.C. Phillips', *Philosophical Issues in Educational Research*, Bentley, Australia: Western Australian Institute of Technology Seminar Series monograph, 1986; and Wylie and Okruhlik's, *"Philosophical Feminism: Challenges to Science," Resources For Feminist Research*, Vol. 16, no. 3 (1987), p. 12-15, for a structural framework to present four leading arguments.

- appeals to the complexity and theory-ladenness of the cognitive processes involved in observation (Hanson, N.R., 1958; Kuhn, T., 1970; and Feyerabend, P., 1975).

The positivistic and operational view that all theoretical terms of science must be reducible to observational language is quixotic. The theoretical concepts of science have meanings that transcend definition in observational terms; if this were not the case, science would have trouble growing and extending into new areas. An operationalist thesis which holds that observation is the "neutral court" which adjudicates between rival scientific claims; perpetuates the option that science is actually built upon the foundation of indubitable observation. Hanson's (1958) thesis was the first to question that theory, hypothesis, or background knowledge held by an observer can influence, in a major way, what is observed.

Subsequent writers have drawn a variety of conclusions from this. Feyerabend (1975), moves into relativist claims. A less extreme view is that, while we must be aware of the role played by our preconceptions, i.e., observation is not "neutral" and "theory-free", and we can still arrive at consensus between rival claims. For example, Israel Scheffler (1967, p. 44) suggests:

> There is no evidence for a general incapacity to learn from contrary observations, no proof of an pre-established harmony between what we believe and what we see . . . our categorizations and expectations guide by orienting us selectively toward the future; they set, in particular, to perceive in certain ways and not in others. Yet they do not blind us to the unforseen. They allow us to recognize what fails to match anticipation . . .

- worries about the underdetermination of theory by observation, especially as these have emerged in the debates over scientific realism (Duhem, Quine, Van Fraassen, B., 1980).

It is becoming increasingly clear that scientific theories are "underdetermined" by nature. That is, whatever evidence is available about nature - nature itself is never sufficient to rule authoritatively between the merits of rival theories. When new evidence arises which necessitates accommodation in theory, there is no specific manner of change that is necessitated - different scientists are free to use their professional judgement and their creativity. This can be interpreted from a more extreme relativist position, i.e., science has no standards, to a less extreme position of understanding that no mechanistic, operationalist procedure is absolute.

- sociological claims that "the facts" themselves, are social constructs shaped by political and social interests (Berger & Luckmann, 1967; Foucault, M., 1970; Schutz, A., 1970; Greene, J. 1971; Latour, B. & Woolgar, S., 1979; Shapin, S., 1979; Barnes, B., 1982; and Latour, B. 1987).

A critical reflection upon the ways in which scientists approach their world demonstrates a perspective that scientific knowledge is socially constructed. A scientist's representation of the world is a perspective or frame of reference which is developed partially by an individual's beliefs, intents, and interests. The construction of meaning therefore for the scientist is idiosyncratic, to some degree.

Barnes (1977) indicates that knowledge is social, a part of culture which is transmitted from generation to generation, and as something which is actively developed and modified in response to practical contingencies. Such a conception indicates that scientific knowledge is not necessarily produced by disinterested, passive individuals but by the social group of scientists involved in particular activities. Knowledge then, is interpreted in relation to reality, the cultural context in which it is developed, as well as the objectives and interests of the social group.

A perspective that has been suggested by individuals such as Schutz (1970) and in Berger and Luckmann's *The Social Construction of Reality* (1967), is that knowledge is socially constructed; that individual's meanings of the common-sense world arise from interpreting experiences within that world.

Again, relativism dismisses scientific knowledge as illusory. A less extreme interpretation is that subjective factors play a role in science, i.e., in the original conception of theory, some preconception from the scientist's environment that serves as a model for constructing hypotheses.

- Neo-Marxist social/political analyses that identify the scientific enterprise, considered as a whole, as a function of context and class-specific interests, and claim that scientific methodology is itself "constituted" by these interests (Marcuse, H., 1960; Smith, D., 1974; and Capra, F., 1982).

This perspective suggests that the processes of theory evaluation are themselves ultimately context and interest-specific. The very procedures for eliminating bias in content are themselves biased, and so, we are threatened with insurmountable context and interest-relativity in the content of scientific knowledge claims.

Dorothy Smith's (1974) social/political analysis argues that knowledge which expands our power of technical control is class specific and empirical. Smith's position is elaborated upon in the feminist standpoint.

Clearly, the very definition of science and the process of scientific change has come under increasing investigation. These considerations challenge the objectivity and rationality of science and arise not from just philosophical, but from psychological, sociological and political concerns.

The Feminist Standpoint

Within the epistemological dimensions of the "new" philosophies of science, another feminist critique emerges. Harding (1986) recognizes that feminist critiques which explore the use and abuse of science, the natural and social sciences, and their technologies, have revealed ways in which science is used in the service of sexist, racist, and classist social projects. Some of these critiques take on an empirical problematic assumption: that there is value-free, pure scientific research which can be distinguished from the social uses of science. This suggests how difficult it is to actually categorize epistemologies into static and neat categories. There is an array of feminist positions, however, reflecting the disarray within the new philosophical thought in science and it is beyond the scope of this work to delineate epistemologically between all of them. The reader is directed to Harding's own treatise, *The Science Question in Feminism* (1986), in which she spends five chapters solely on this point.

More simply, Harding (1986, p. 26) identifies a current feminist trend which challenges men's dominating position in social life:

> Briefly, this [trend] argues that men's dominating position in social life results in partial and perverse understandings, whereas women's subjugated position provides the possibility of more complete and less perverse understandings. Feminism and the Women's Movement provide the theory and motivation for inquiry and political struggle that can transform the perspective of women into a *standpoint* - a morally and scientifically preferable grounding for our interpretations and explanations of natural and social life.

There are several feminist science theorists who incorporate the standpoint position into their perspectives, as well as a leading theorist, Dorothy Smith, who

reflects the immediate standpoint epistemology. For an understanding of this epistemological orientation, the researcher will elaborate upon these theorists, only.

Ruth Hubbard (1979, 1984) reflects upon the patriarchal social and scientific context in which biologist's perceptions of reality are structured. She asserts that the rapprochement between biology and the social sciences is placed within an androcentric context and she questions the gender-specific assumptions and expectations based on a patriarchal gender ideology. She comments on the role which scientific language plays in the construction of a sexist reality and suggests that the missing questions which the biological linguistic structure conceals are, "by whom, for what purpose, in whose interests, under what conditions?" (1979, p. 214) Hubbard asserts that we must examine the androcentric basis of scientific language and provide answers to these questions.

Hubbard (1979) exposes and analyzes the male myths in the extrapolation of Darwinian selection theory to the evolution of female behaviour. She exposes a Victorian stereotype that runs throughout the literature of human evolution. In particular, Hubbard situates Darwin in his social time and place; within the social and political ideology of nineteenth century Britain and with Victorian precepts of morality. She acknowledges the ethnocentric, patriarchal bias of Darwin.

Hubbard stresses science as a social construction, an historical enterprise that reveals the intellectual, moral, and political projects of science as creating sexism, classism and racism. She exposes the picture of the active male and the passive female, suggesting that the very focus on sex differences is itself a reflection of distinctively masculine projects.

Assumptions about the biological nature of men and women have been challenged within the discipline of sociobiology and seen as attempts to justify submissive and inferior female roles; a double standard in sexual morality. Sarah Hrdy[12] (1981), an anthropologist, challenges basic primate social structural stereotypes. She argues that in many primate societies, females enjoy greater autonomy than do either men or women, in human society.

Evelyn Fox Keller (1978, 1982, 1985) points out that scientists and philosophers project a defensive masculinity onto their activities. In *Reflections on Gender and Science* (1985), Keller devotes a chapter to Baconian Science and the Arts of Mastery and Obedience. In this chapter (p. 36), she explains that the Arts are associated with sexual pleasure, the sciences with sexual restraint, antithetical to Eros. For the scientist to be seen as masculine, Bacon establishes a chaste and lawful marriage between Mind and Nature, where Mind, the virgin groom, dominates the eros of nature, subjugating her. These metaphors evolve into powerful definitions of science and its methods of inquiry.

In Keller's works, the structure, ethics and politics of science take on a distinct androcentrism. Keller suggests that the basic dualism which posits a subordinance/dominance relationship in women/men mystifies and maintains

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[12] Sarah Blaffer Hrdy. *The Woman That Never Evolved*. Cambridge, Mass.: Harvard University Press, 1981. Hrdy challenges four basic social structural stereotypes in primate societies:

i) the dominant male is obviously the central figure in a population's persistence over time

ii) competition is peculiar to the male sex

iii) female hierarchies are less stable

iv) a female's status changes when she is in estrus, reflecting that of the male consort

patriarchal relations by means of its very coherent, philosophical and scientific model of discourse. Dualistic thinking is central to Western philosophies, to science, and to its institutions. Science reaffirms its masculine-dominant practices through purportedly objective scientific rationale.

Ruth Bleier (1984) has also argued that this kind of dichotomizing has constructed a science which represents these dualisms:

> Science is the male intellect: the active, knowing subject; its relationship to nature - the passive object of knowledge - is penetrated by the principle of domination. It has defined itself as the epitomy of the very gender dichotomies that it sets about to "objectively" investigate and explain: manipulation, control, and domination - the relationship of man to woman, of science to nature . . . (p. 196).

Bleier states that these dualisms, subject/object, science/nature, and active/passive are all symbolically descriptive of the central male/female dichotomy and the oppositional relations of dominance and dominated. This symbolism structures our approach to knowledge, it structures the world itself and women's place in it. It imposes an *a priori* premise onto the organization of a natural world and here lies the fundamental signification: scientists are not as culturally-disengaged nor as gender-free from the questions they ask of nature, or the methods they use to frame their answers, as a patriarchal paradigm would like us to assume.

Much of the discussion amongst these feminist scholars centres on the deeply held doubts about the legitimacy of treating science as the final authority in adjudicating claims to knowledge and rationality in our culture. Keller, Bleier and Hubbard are a few of the feminist theorists (see also Ardener, S., 1975; Reed, E., 1978; Merchant, C., 1980; Spender, 1980; Jaggar, A., 1983; and Rosser, S., 1984) who

argue that far from being disinterested, the very canons of scientific rationality reinforce and legitimate existing patriarchal power structures. Indeed, the "objective" strategies used by Science to establish knowledge claims are profoundly interest- and theory-relative. They also suggest that if our culture is structured by patriarchal interests, science must be androcentric.

Evelyn Fox-Keller (1982, 1985) presents one of the more sophisticated philosophical analyses. She turns to object relations theory[13] for a conceptual framework in which to articulate the insight that the whole impulse of science to objectify and manipulate reality, arises from distinctively male processes of psychological development and enculturation. The point of departure for Keller's analysis of the psychological relativity of science as a human enterprise is a review of the arguments about theory-ladenness of observation and underdetermination of theory by evidence, presented by Kuhn (1970), Feyerabend (1975), and others. However, her psychoanalytic argument goes beyond the developed argument within the philosophies of science, to bring new insights to interest-relativity in science; i.e., androcentric interest. It also presents us with ontological dimensions in philosophical argument. Although Keller touches on "being"; the dualisms of reason/intuition (emotion); mind/matter; nature and culture, and the effect on

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[13] Evelyn Fox-Keller. *Reflections on Gender and Science*. New Haven: Yale University Press, 1985, p. 96. Keller develops a sophisticated argument suggesting, "that the use of the word 'object' to denote another subject (first and foremost the mother) - a use that object relations theory inherits from Freud - affects scientific discourse. Objectivity leads to control and domination since the cognitive claims of science are not themselves objective in origin but in fact grow out of an emotional substructure. The scientist is not the purely dispassionate observer he idealizes, but a sentient being for whom the very ambition for objectivity carries with it a wealth of subjective meanings."

woman's place/woman's "being" in science - the ontological concepts are not fully developed within the standpoint feminist critiques; they are developed to their fullest potential in post-modern feminism, in the next discussion.

Harding (1986, p. 122-23), suggests that Keller replicates traditional internalist history by ignoring the social, political and economic constraints that explain why some scientific ideas gain social legitimacy and others do not. And it is here that the standpoint view becomes more clearly developed. One of the leading theorists in the standpoint view, Canadian sociologist of knowledge, Dorothy Smith (1979), constructs a science that begins from the "standpoint" of women. Though her stated concern is sociology, her arguments are generalizable to inquiry within science.

Smith (1979) avoids psychoanalytic arguments which fashion subject/object, nature/culture, reason/emotion dualities of enlightenment science. Rather, she focuses on the structure of the workplace for women scientists; her ideology based on Neo-Marxist notions of labour and classism. Smith envisages a notion of the materialist conditions necessary to make possible a distinctively feminine science. By recognizing the master/slave, classist relationship, where the slave's labour is simply an extension of the master's being, Smith suggests that women are excluded from man's conception of culture; women's endeavours are distorted abstractions of men's conceptual schemes. For Smith, education for women, completes the "invasion of women's consciousness by ruling-class experts" (1979, p. 143).

Smith[14] suggests that in order for women to engage in a distinctively feminist science, women must recognize the experiences of their own activity; that is, women

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[14] Sandra Harding, 1986, p. 157. An account of Harding's synthesis of Smith's thoughts.

are first of all - females, who "maintain" their own bodies and their own domestic places for their children and men. When entering the world of science, women are trained to operate experientially within male conceptual schemes, which they do not recognize. An account of "housework", for example, from the "standpoint of women" would be different from a man's interpretation. Hence, moving into a masculine science would be a quite different account, where women are the voice of the "inquirer" rather than the "subject of inquiry."

Harding's (1986, p. 157) philosophical critique of this epistemological view is important:

> Once Smith puts the authority of the inquirer on the same epistemological plane as the authority of the subjects of inquiry - the woman inquirer interpreting, explaining, critically examining women's condition is simultaneously explaining her own condition - the issues of absolutism vs relativism can no longer be posed. Both absolutism and relativism assume separations between the inquirer and subject of inquiry that are not present when the two share a subjugated social location.

Harding (1986, p. 158) suggests that ". . . what feminism should distrust is not objectivity or epistemology's policy of thought per se, but the particular distorted and ineffectual form of objectivity and epistemology entrenched in Enlightenment Science." Hence, alternate epistemological versions of women's "reality" should be regarded as producing more complete understandings than ruling-class masculine scientific activity.

Included within the standpoint position are liberal and neo-marxist feminist attempts to show the many aspects of economic, political and social shifts that have created the science we envisage today. Several authors (Arditti, R., 1980; O'Brien,

M., 1981, 1983; and Rowland, R., 1985) have examined the patriarchal, capitalist and imperialist motives controlling distribution of birth control, the politics of abortion policies, and reproductive technology in general. Harding suggests that while many views are indeed educational, some of the accounts retain too much of their Marxist "legacy", hence, Marxism's inherited "Enlightenment Science" and tacit empirical underlyings.

The feminist standpoint epistemologies are grounded in those shared characteristics of *women as a social group* and *men as a social group*. This becomes problematic when we recognize that the two groups are not as dichotomous as we would like to think, in that we/women's "experience" is articulated by men. Is it really possible to have a feminist science?

Feminist Post-modernism

Harding's third epistemological framework for inquiry challenges feminist empiricism and the feminist standpoint views, and emerges out of post-modern theory. Mainstream theorists, such as Derrida, Foucault, Lacan, Culler, Rorty, Gadamer, and their spawned intellectual movements, deconstruction, neo-psychoanalytic theory, post-structuralism . . . become tools in analyzing claims about the existence, nature and powers of reason, language, and the "self" in relation to "other". It would not be in the scope of this paper to discuss and critique all of the above mentioned post-modern theorists, however, the researcher will highlight some of their epistemological and ontological commonalities and the implications for feminist theory in science.

Post-modern theory requires us to embrace as a fruitful grounding for inquiry, the distorted and fractured meanings of our existence. This line of thought revives existentialist philosophies and therefore presents ontological dimensions of "being", which speak to us as individuals. Hans-Georg Gadamer in *Critical Sociology*[15] (1976), drawing from Heidegger, develops a form of existential hermeneutics emphasizing the meaning for us as individuals, of historical text. "Meaning" becomes a key word, in a number of theorist's works (Derrida, Lacan, Culler), in that a realization of the distortion and exploitation perpetrated on behalf of fictionalized "texts", whether they be literary narratives or societal institutions or the individual (and the term "text" has been used to metaphorically "read" all three), can be used to reconstruct less distorting meaning, albeit highly idiosyncratic meaning. The point is to deconstruct, expose fictional interpretations motivated by empirical or traditional epistemologies.

Feminist critiques emerging from post-modern theory, such as French literary criticism, are concerned with the repression of the feminine; they rely on analytic methods that isolate psychic symptoms, such as the gaps and silences that signify the absence of the female voice in texts, or the textual eruptions and incongruities that signify the return of the repressed. Much critical effort is devoted to what is perceived as deconstructing the dominant masculine discourse (see Monique Wittig's *Les Guerilleres* in Homans, M., 1980; De Lauretis, T., 1984, 1986).

Feminist post-modern interpretations explore women's relationships to knowledge, to "objects" of study, to knowing, i.e., metaphorically "the narrative".

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[15] Heidegger's existential phenomenology focuses on the "nature of being" within the "life-world" and questions our actions and choices. Alfred Schultz (1970) develops this notion, emphasizing the role of common-sense beliefs and practices in the social construction of reality.

These are relationships of mutuality rather than "invasiveness" and dominance. If women are attuned to being the "object", this disempowerment leads to exclusivity and separateness as cognitive frameworks and modes of perceiving and understanding the world, as contrasted with mutual relationships of inclusiveness and contextuality. Women's mutual experience places them in a perspectival framework different from, but no less legitimate than that of the androcentric experience.

Our understandings of knowledge forms, of "ways of thinking and knowing" have been challenged by subversive techniques in getting at meaning. Feminist post-modernists are particularly acquainted with aggressions on texts and societal constructions which drastically restrict individual freedoms. Their theoretical contributions to a text, i.e., science, which restricts epistemological freedoms, is timely.

Luce Irigaray, for example, in *Speculum of the Other Woman* (1985), riddles her work with puzzling imagery, there are no grammatical codes or punctual systematicity. She wishes, ". . . to confound, once again, the 'imaginary of the subject' - in its masculine connotation . . . " (p. 365). Irigaray criticizes the monistic impulse in phallocentric theory. This means that she deconstructs Freudian psychoanalytic and Lacanian theory: we/women are seen as a speculum or reflected image of an "other woman", defined and articulated in male terms:

> One might begin by being surprised, being suspicious, that it should be necessary to "become a woman" . . . and that this evolution should be more difficult and complicated than becoming a man. This is again a question that arises out of an economy . . . of representation - to which Freud has recourse without criticism, without sufficient questioning . . . this is an organized system whose meaning is regulated by paradigms and units of value that are in turn determined by male subjects. Therefore, the feminine must be deciphered as inter-dict: within the signs or between them, between the realized meanings

between the lines . . . and as a function of the (re)productive necessities of an intentionally phallic currency . . . " (p. 22)

Irigaray describes the male preoccupation with the life and death of the penis and the projections into other aspects of culture which this imbibes: in the need for immortality and posterity. Gallop (1982)[16] also suggests that the male economy is impatient for products, definitive statements and conclusions: these are constructs not familiar to females. The narrator, in her attempt to understand female desire, discovers man's obsession with his penis . . . and its power to control women. Metaphorically, then, how to combine desire with power becomes a major question for women; it is a problem in terms of the authority of their narrative technique.

The feminist post-modern critiques begin dialectically with analyses of we/women's ambiguous relation to power as it is reflected in the language and structure of our works. Where is the female voice; her authenticity; her authority?

In science, it is closely bound with the male voice: a central voice. Women's marginal inner voice unveils the male phallus with its dominating symbolic resonance, to construct a test with a different narrative pattern, an estrocentric view of a natural, scientific and social reality which includes an ontological dimension; it occurs within human existence and any attempt to unveil it must acknowledge that the questioner's own being is in question.

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[16] Jane Gallop. *The Daughter's Seduction: Feminism and Psychoanalysis*. Ithaca: Cornell University Press, 1982, p. 12. Gallop argues that "feminine sexuality, the alternative or rival to (always masculine) desire is characterized by contiguity. Feminine sexuality therefore, unlike the mediation of the visible which sustains phallic desire is of the register of touching, nearness, presence . . . extended culturally, such desire alters production and makes of praxis an immediate pleasure."

A post-modern feminist narrative on science then challenges the text: it's authenticity, it's authority, it's stance. The current characterization of science: scientific = objective = masculine, affects our evaluation of masculine and feminine being. If science receives a validation from the gendered preference of masculine, of what signification does a feminine world view hold for a model of science?

Harding (1986, 1987), too moves towards post-modern feminist interpretations, acknowledging that our fractured identities are inclusive in the hyphenization of feminist political and theoretical stances, e.g., Socialist-Feminism, Radical-Feminism, Lesbian-Feminism, Black-Marxist Feminism, Black-Lesbian-Socialist Feminism, Radical-Women-of-Color. Although contradictory tendencies amongst these feminist stances lead to contradictions within epistemological discourses, Harding suggests that they reflect shifting configurations of gender, race and classes, in both the analytical categories and in the lived realities:

> New social groups - such as feminists who are seeking to bridge a gap between their own social experience and the available theoretical frameworks - are more likely to hone in on "subjugated knowledge" about the world than are groups whose experience more comfortably fits familiar conceptual schemes. Most likely, the feminist entrance into these disputes should be seen as making significant contributions to clarifying the nature and implications of paradoxical tendencies in contemporary intellectual and social life (1986, p. 28).

Harding accepts that the feminist criticisms in science have produced an array of conceptual questions that question a democratic and socially-progressive society and also threaten our core personal identities as gender-distinct individuals. Collectively, this has allowed we/women to grasp the extent of androcentrism in

science and made it possible to formulate new questions about feminism and science.

Harding (1986, p. 244) also suggests that it would be premature and delusionary for feminism to arrive at a "feminist scientified unified master theory" ["at a Kuhnian 'normal science paradigm', with conceptual and methodological assumptions"]. In fact, she suggests that feminist analytical categories are unstable at present and should be, at this point in history. They help us to transform various patriarchal theories (Marxism, Psychoanalysis, Empiricism) rather than simply revise them. The post-modern theorists have helped we/women to examine the worlds of particularity and of psychic repressions and fantasies that constantly intrude, only to be insistently denied in the scientific world view.

The goal of feminist knowledge-seeking then is to achieve theories that accurately represent women's narratives. Harding states that: ". . . the destabilization of thought has often advanced understanding more effectively than restabilization, and the feminist criticisms of science are a particularly fruitful example of an arena in which the categories of Western thought need destabilization . . . (1986, p. 245).

The hegemony of scientific thought quickly forces we/women to question the most fundamental assumptions of modern Western thought. Valuable tensions lead us to integrate the science question into feminism rather than to impose a feminist master theory on science. As Harding suggests (1986, p. 245):

> . . . it has been assumed that anything and everything worth understanding can be explained or interpreted within the assumptions of modern science. Yet there is another world hidden from the consciousness of science - the world of emotions, feelings, political values; of the individual and collective unconscious; of social and

historical particularity explored by novels, drama, poetry, music and art - within which we all live most of our waking and dreaming hours under constant threat of its increasing infusion by scientific rationality. Part of the project of feminism is to reveal the relationship between these two worlds - how each shapes and [in]forms the other . . .

CHAPTER 3

CONCEPTUAL FRAMEWORK OF THE STUDY (PART II): INTEGRATING SCIENCE EDUCATION INTO FEMINISM

Introduction

Like science, science education operates on a series of increasingly complicated levels that require decoding; its narrative patterns are reminiscent of the metaphorical dualisms, the spatial restrictiveness and the closure with which students come to understand meanings. To break down the reified authoritative patterns which have objectified knowledge, involves questioning established canons. Marcuse (1960) states:

> Since the established universe of discourse is that of an unfree world, dialectical thought is necessarily destructive, and whatever liberation it may bring is liberation in thought, in theory. However, the divorce of thought from action, of theory from practice, is itself part of an unfree world. No thought and no theory can undo it; but theory may help to prepare the ground for their possible reunion, and the ability of thought to develop a logic and language of contradiction to a prerequisite for this task . . .[1]

As a critical theorist, Marcuse is rooted in an aversion to all forms of domination. Henry Giroux (1983) points out that Marcuse's challenge centers around the need for educational practitioners to develop modes of critique fashioned in a theoretical discourse, that mediates the possibility for social action by

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[1] Herbert Marcuse, in Henry A. Giroux. *Theory and Resistance in Education: A Pedagogy for the Opposition*. Massachusetts: Bergin and Garvey Pub., 1983, p. 2. For Marcuse's own discussion of the dialectic, see *Reason and Revolution*. Boston: Beacon Press, 1960.

questioning traditional ideologies. In science education, that is not easy, informed as it is by a long tradition of patriarchal, ideological discourse and technological, social practice that promotes an objectified knowledge, knowledge which separates the knower from her knowledge.

This chapter outlines theoretical science teachers' paradigms. To teach the 'reading of science stories' is a major task of feminist inquiry. Metaphorically, 'ways of seeing', will thus be altered. We can question the separation of educational 'knowing' from 'knowing' acquired through we/women's lived experience. Understanding that principles of duality, hierarchy and competition have framed the parameters of the kinds of patriarchal science educational models we confront, can lead us to develop, in Marcuse's words, "a language of contradiction", where, as a prerequisite for curriculum transformation, we can freely question the theory/practice, objectivity/subjectivity dichotomies.

If we/women can appreciate how students of science come to accept certain meanings, then we have a basis for helping them to learn different meanings. If we aim to challenge the consciousness of our students so they can recognize the divisions patriarchal ideology has created, then where ideology operates, we can address ourselves to contradictions, to questions of learning. There is a special contribution that a feminist inquiry into scientific 'ways of knowing' can make. The feminist critique can sit itself quite firmly at the juncture between science curriculum theory and practice: the possibility of real dialectics within which a total, specific, 'feeling and thinking' subject, present in her interaction with 'objective materials', mediates the possibility for social action and emancipatory transformation. This transformation of educational practice in science, requires not only a redefinition of

women's place in science, but a redefinition of science. This includes a critical reflection upon science and technology within a global ecological context, with a dialectics in our educational practice which reflects this context. Convergently, these emancipatory moves - feminist, ecological, educational, rely on each other. One is not exclusive of the other. This, in turn, has profound implications for the teaching of science.

The Reading of Science Stories

The true story lies
among the other stories

The true story is vicious
and multiple and untrue[2]
(Margaret Atwood, *True Stories*)

The poem alerts we/women to the decoding process necessary to a reading of the 'textual body' of science and therefore to the meaning this holds for our students in the classroom. The demystified themes that emerge from a reading of the text, the subjugation of nature/of women, significantly connect with the works of contemporary feminist science philosophers. Indeed, post-modern feminists insist upon a deconstructive tool, such as decoding narrative structures, to analyse claims about the existence, nature and power of knowledge claims.

Metaphorically then, the stories or narratives told by science practitioners, superficially follow narrative logic and although they give the student reader a plot,

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[2] Margaret Atwood, lines from *True Stories*. Toronto: Oxford University Press, 1981, p. 11. It is quoted in Lorna Irvine's *Sub/Version*. Toronto: ECW Press, 1966, p. 44.

that plot is profoundly misleading. A number of questions need to be answered. What, for example, does the reader gain by stripping down the layers of text? What is gained by assessing the political connections between science and society, science and technology, technology and society? Where is the female voice; her authenticity? her authority?

Perhaps, as Atwood (1981), Irvine (1986), and Pagano (1988) have suggested, our first goal is to accurately represent women's narratives, to impression new units of meaning upon our fixed conceptual schemes and frameworks. The re-reading of a text, (i.e. science) can signify the shifting of focus from the central to the peripheral limits of language; hence, metaphorically, shifting epistemological awarenesses from the central to the marginal. The re-reading of science stories has already been attempted by a number of educational scholars.

Theoretical Science Teacher's Paradigms

In *Seeing Curriculum In A New Light: Essays from Science Education* (1980), Hugh Munby suggests that the notion of "seeing things differently" is central, in that alternate theories can cause individuals to look at familiar events in a different light. He asks teachers to use philosophy as a "lens", to examine the philosophical meaning and/or epistemologies which emerge theoretically, to see what they might contribute to science teaching practice:

> This notion of "seeing" is central to the present argument. The fashion in which theory can cause us to look at familiar events differently is well exemplified in the philosophy of science . . . When we take [the philosophy of science] challenge seriously we begin to understand the sort of contribution an educational science can make: it can ask that we put aside customary and sometimes comfortable ways of looking at phenomena and that we adopt a new perspective so that our view of

> the phenomena is changed to enable one to understand them differently.[3]

Munby's point is important because it alerts us to the complexity of belief systems, insofar as a world view of a teacher represents a philosophical epistemology.

Munby suggests that the dominant perspective used to answer educational theoretical questions borrows techniques of experiment and measurement from the physical sciences. Indeed, he suggests that the prevalence of this perspective has styled a 'scientific paradigm' of educational research. Munby uses philosophy to explore alternate perspectives in conceptual analysis of educational practice. He also explores the use of language as a means of 'talking' differently about educational phenomena. In an attempt to bridge the theory/practice gap, Munby provides an analysis which places paramount emphasis on the intellectual integrity of the student: an outcome achieved by exploring alternative paradigmatic criteria.[4]

Munby's work draws on earlier theorists - Schwab (1960), Scheffler (1965, 1967), Kneller (1964), Novak (1977), Roberts and Russell (1975) - all of whom suggest that the typical scientific educational research paradigms need to be

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[3] Hugh Munby, from his Introduction in Munby, Orpwood, Russell, eds. *Seeing Curriculum In A New Light*. Toronto: OISE Press, 1980, p. 3-4. Munby discusses Toulmin's (1960) example of the principle that light travels in straight lines, a principle to which we are so accustomed that it pays to look at it again carefully. In this principle, one can find a use for inferences and questions about optical phenomena . . . physical science is not just a systematic exposure of the sense to the world; it is also a way of thinking about the world, a way for forming conceptions.

[4] Hugh Munby, from *Analysing Teaching for Intellectual Independence* in Munby, Orpwood, Russell, eds. *Seeing Curriculum In A New Light*. Toronto: OISE Press, 1980, p. 11-13. Munby distinguishes between features of intellectual dependence and Intellectual Independence; the former represented by absolutism of empirical evidence, the latter relying on critical reflection and judgement with regard to reason.

challenged. In relation to educational practice, many of these theorists include alternate epistemological approaches to teaching. Respecting student's intellectual integrity necessitates that teaching discourse incorporate alternative paradigmatic criteria. For example, Scheffler (1965, p. 131), in *Philosophical Models of Teaching*, suggests that:

> . . . teaching may be characterized as an activity aimed at the achievement of learning and practiced in such a manner as to respect the student's intellectual integrity and capacity for independent judgement. Such a characterization is important . . . it differentiates the activity of teaching from such other activities such as propaganda, conditioning, and indoctrination, which are aimed at modifying the student but strive at all costs to avoid a genuine engagement of [his] judgement on underlying issues.

Perhaps the most salient argument for exploring alternate 'ways of seeing', both in educational research and in classroom practice, is the very notion that so much of what takes place in science educational reading and in science classrooms leaves the learner dependent upon teacher authority, for assessing the truth of knowledge claims transmitted. And these knowledge claims are inevitably Western, materialist and masculine in nature.

Desautels and Nadeau (1984), in *Epistemology and the Teaching of Science*, suggest that in order for our science educational choices to be theoretically critical, they must be made in view of the delineation and examination of alternative epistemological criteria. Desautels and Nadeau articulate the features upon which a positivistic, mechanistic science contributes to Western culture's sense of reality and suggest that science teaching reinforces beliefs and myths that are inherent in

scientistic ideology.[5] An important issue for these authors, is the questioning of the mechanistic provisions under which students assess the truth of scientific knowledge claims. They recognize the importance of presenting alternative analyses which can allow for conflicting conceptually constructed meanings.

Both Desautels and Nadeau encourage science teachers to create a cognitive disequilibrium within the student, where conflicting conceptual meanings can create new epistemological awarenesses.[6] They encourage teachers to be self-critical; to help students recognize the limits of validity within scientific practice; to discourage dogmatic reliance on technocratic and elitist ideology.

The Classroom Functional Paradigm

Robert Crocker's (1983) reformulation of the term 'paradigm', in research on science teaching, has significance for classroom practice. His research helps to set a path towards more critical thinking about teaching. In attempting to bridge the theory/practice gap, Crocker recognizes that the paradigms of educational theorists may be different from the actual nature of the paradigms under which teachers may operate. An understanding of a teacher's functional paradigm may then be useful.

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[5] Scientistic ideology, here defined by Desautels and Nadeau in *Epistemology and The Teaching of Science*. Ottawa: Science Council of Canada, 1984, p. 8, incorporates Pierre Thuillier's definition: "scientistic ideology is a virtually blind faith in the cognitive and moral value of science."

[6] Desautels and Nadeau suggest that, "conceptual change within the student cannot occur unless a state of relevant cognitive disequilibrium is induced. This cognitive disequilibrium is only effective when it has some significance for the student, that is to say, when the difference between expectations and the information obtained in interaction is associated with strongly held belief" (1984, p. 54-55).

Crocker advances the concept of a Functional Paradigm - wherein teachers interests may be founded in practical matters rather than in theory. Crocker's application of the term 'paradigm' from its theoretic context, to distinguishing it in relation to classroom functioning, assumes that teachers are similar to other practitioners in sharing common beliefs, values, exemplars, and routines. These notions can help explain classroom functioning. Teachers functioning in a particular paradigm offer a model for their colleagues and students. Diverse models of science teaching can be implemented but the wider introduction of innovative epistemological and pedagogic strategies meet the competition of the established paradigm and may fail because of lack of support from the broader community of practitioners.

An assessment of the nature and sources of the functional paradigms of teachers has been a major consideration of a number of research projects (Driver, R. & Easley, J., 1978; Connelly, M., 1980; Roberts, D., 1980; Benson, G., 1984; Lantz, O. & Kass, H., 1987; Tomkiewicz, W., 1987). The concept of a functional paradigm provides a means of interpreting why teachers and classrooms function as they do. The influence of the teacher on the student is a result of many variables: the interpretation of curriculum materials by the teacher and the student; the teaching strategies employed - the pedagogy; the teaching and learning situation - the environment; and the teacher's and student's backgrounds. This is based upon Schwab's (1973, 1978) earlier identification of these variables as four commonplaces: subject matter, teachers, learners and milieu. The practical matters of the functional paradigm then, have a foundation in these four commonplaces, which provide a framework for conceptualizing the phenomena of teaching.

Connelly (1980) argues that curriculum developers' elaborate theoretical constructs of society, knowledge, teacher and learner, are not effectively translated by users (teachers), because the user's conceptual images are translated through their own set of instructional frameworks and world views. Lantz and Kass (1987) agree that an examination of the conceptual meaning that science curriculum materials have for classroom teachers may contribute to a better understanding of the functional paradigms of science teachers.

It is the conceptual framework of the teacher, the interpretive schema through which a teacher reconstructs a curriculum, and the knowledge or world view of the teacher, that holds significance for a feminist inquiry. The feminist critique, can sit itself at the juncture between science curriculum theory and practice: the possibility of real dialectics with a total, specific, feeling and thinking subject, present in her interaction with 'objective' materials. This juncture is a point of transition, a critical moment whereby feminist theoretical understandings can reveal the marked boundaries of teacher practice and open up the functional paradigms of teachers to new understandings.

Douglas Roberts (1980) in *Theory, Curriculum Development, and the Unique Events of Practice*, suggests a model of teacher interpretation which he refers to as the 'developer-teacher interface'. In this model, curriculum developers communicate intentions, however, teachers decide whether to reject or modulate the materials developed for them. In this model, teacher's functional paradigms serve as the interface which determines how curriculum materials will be translated into classroom practice.

This model is complete in assessing the curriculum materials, the teaching milieu, and the teacher's background. These events are interpreted within the teacher's functional paradigm and guide classroom practice. Within the teacher's functional paradigm then, is the interpretative framework which guides the teaching process. This includes the epistemological perspectives the teacher brings to the classroom experience and this in turn is defined by the teacher's world view.

Theorists such as Desautels and Nadeau, Munby, and Roberts recognize that the adoption of epistemologically critical approaches to science teaching challenge dominant functional classroom paradigms. For contemporary epistemology to provide the conceptual framework for such a critical approach, a recognition of the autonomy of mechanistic and positivistic knowledge claims, must be made.

A Feminist Reading of Text

And where do these knowledge claims come from? Ruth Bleier, in *Lab Coat: Robe of Innocence or Klansman's Sheet?* (1986), reminds we/women of the knowledge claims of our scientists, science advisors and hence science educators:

> James Watson, it seems, is now unhappy . . . for its regulations governing genetic engineering and . . . remarked that . . . the person in charge . . . is either a woman or unimportant. [This] exchange may serve as an eloquent reminder of the implacable misogyny that characterizes science and some of its prominent spokesmen; of the relative imperviousness of the natural sciences . . . to its critics who are feminists or [neo]-Marxists or other radical political commentators, and of the enormity of our feminist task, to reconstitute knowledge in the sciences.[7]

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[7] Ruth Bleier. *Lab Coat: Robe of Innocence or Klansman's Sheet?*, in T. DeLauretis (ed). *Feminist Studies/Critical Studies*. Bloomington: Indiana University Press, 1986, p. 55-56.

Certainly, the adoption of epistemologically critical approaches to science teaching challenges the autonomy of the mechanistic, scientistic paradigm, allowing educators to critically examine their world views. But for we/women, any interpretation is inextricably bound with the power within a patriarchal framework. In *Feminism and the Power of Interpretation: Some Critical Readings*, Tania Modleski (1986) points out that women have been held prisoners of male texts, genres and canons. Modleski suggests that this fact of power renders asymmetrical the process by which men and women acquire competency to read each other's texts and guarantees that the majority of men will not really appreciate women's texts, since there is no compelling reason for them to begin to be interested in what women have to say.

Modleski goes so far as to suggest that the act of interpretation itself is a patriarchal enterprise; the goal of which is to achieve power and mastery over a given text:

> . . . In this theoretical schema, the text-writing in general - is identified with femininity, and interpretation becomes a means of arresting the free play of meaning analogous to the way patriarchy continually attempts to contain women and women's sexuality.[8]

In developing this thought, a feminist inquiry would elucidate the ongoing process that makes up female subjectivity; feminists at this historical moment need to insist on the importance of women as interpreters of text. Modleski advises we/women to conduct a thorough and honest analysis of the way in which men's gender shapes

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[8] Tania Modleski. *Feminism, the Power of Interpretation: Some Critical Readings*, in T. DeLauretis (ed.) *Feminist Studies/Critical Studies*. Bloomington: Indiana University Press, 1986, p. 126.

their and our interpretations in order to truly demonstrate the limitations of male critical interpretations.

Metaphorically then, a feminist 'reading of text' has implications for the knowledge claims we might perpetuate as science educators. This, in turn, has profound implications for the teaching of science. There are compelling reasons for feminists to be wary of theories that require women to read, (to teach) as men. It is here that the attempt to integrate the science educational question into feminism takes on meaning. Rather than impose feminism on science educational research phenomena, it is important to recognize the ontological dimensions of women's experience . . . what educational science stories can we/women relate to, which authenticate our various life roles. Most science educational research analyses, up to this point, impose an *a priori* set of premises upon patriarchal-framed inquiries. Even pluralistic orientations to examining science educational phenomena (Eisner, 1979; Roberts & Russel, 1975; Schwab, 1978; Munby, 1980; Roberts, 1980; Desautels & Nadeau, 1984), delineate and examine alternative epistemological criteria within patriarchal paradigms. And here again is the question of the female voice . . . Where is her authenticity? . . . her authority?

Perhaps we/women can start by simply telling our narratives from our own interpretive frameworks. In teaching science to our students, what constitutes our own world views? To what extent are these world views an extension of men's stories? What is our 'own'? The researcher will outline a textual critique in which metaphors of gender politics in the narratives of everyday women science teachers are no longer read as individual idiosyncrasies, but as relevant meanings in which

science teaching is inextricably bound with specifically masculine and Western ideologies.

Feminist criticism and theory play a crucial role in the process by which women's experience is made conscious, articulated, and constructed. In the life of the everyday women science teacher, an analysis of underlying patriarchal orderings of scientific knowledge claims, can empower we/women to incorporate alternative epistemological perspectives into our classroom functional paradigms. Indeed, Modleski (1986) suggests that our own subjectivity is an ongoing construction, not a fixed point of departure or arrival from which we interact with our world. Modleski suggests then that,

> By working on a variety of fronts for the . . . empowerment of women, feminist criticism performs an escape act dedicated to freeing women from all male captivity narratives, whether these be found in literature, criticism, or theory (1986, p. 136).

As science teachers, this consciousness raising can free us to authenticate our own science teaching narratives and to explore new ones.

CHAPTER 4

METHODOLOGICAL FRAMEWORKS OF THE STUDY

Introduction

Chapter 1 frames the research question within a feminist methodological mode of inquiry. Chapters 2 and 3 articulate the conceptual framework for the research. This chapter provides the research design: the premises for the analytical scheme used as well as a description of this scheme. This chapter also provides a description of the research events; the pre-entry, entry and validation procedures.

Research Design

A Feminist Analytical Schema

In keeping with a qualitative research orientation, as outlined in Chapter 1, the analytical scheme that is employed in this gender-related analysis, recognizes the significance of hermeneutics in unfolding women's narratives. Meaningful description and interpretation of events and phenomena are the 'texts' by which women's teaching narratives are revealed. It is the authenticity of the female voice - her authority which is heard in the narratives in this study.

At the same time, a critical orientation is engaged, in probing for underlying patriarchal bases in order to reveal tacitly held intentions and assumptions. In order to uncover what knowledge is legitimated by the teacher and to uncover tacit

interests of power and control, a feminist analytical schema is employed which reveals women science teachers' experiences.

Women Teachers' Texts

To uncover what knowledge is legitimated by the teacher then; to uncover the interests being served - a very useful analytical schema was employed by Garth Benson in *Understandings of Biology* (1984). In this study, three teachers' epistemological paradigmatic frameworks were uncovered, very successfully, through Benson's application of Esland (1971) and Werners' (1978) analytical schemes.

Esland presents a case study methodology in which he asserts that the examination of teacher's subject and pedagogical perspectives reveal essential categories of thought through which sense is made of teaching and learning processes. It includes examining teachers' lesson presentations, informal discussions and classroom observations. Werner incorporates the Habermasian orientations, recognizing that subject and pedagogical perspectives are developed by a person's beliefs, intents, and interests - meaning therefore becomes highly idiosyncratic to the individual teacher.

Feminist inquiry recognizes that meaningful description - a hermeneutical approach - is useful in revealing women's stories and the premises of Benson's analytical scheme[1] are grounded in the sociology of knowledge, hermeneutics and

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[1] See Garth Benson. *Understandings of Biology*. PhD dissertation, p. 91. The first premise assumes that knowledge and social structure are related in such a way that they influence each other. The second premise assumes that the process of interpretation involves the analysis of meaning shared through communication. The third premise assumes that biological knowledge is socially constructed and the fourth premise assumes that individual's meanings of the common sense world are reconstructed linguistically and that they are revealed in linguistic description.

sociolinguistics. Within this scheme, a series of questions are asked which attempt to reveal the underlying perspectives which control, maintain and legitimate social relations between the teacher and the students; and the sources or criteria for these perspectives, hence the scheme also incorporates a critical orientation which reveals underlying meaning.

The scheme is based on the assumptions that - a teacher develops an epistemological position which is interpreted by the researcher; a teacher's interpretation of a discipline is related to her epistemological position; and a teacher does not present the subject content unaltered, i.e. her interpretations of knowledge are reflected in the lesson presentations (Benson, 1984, p. 95).

The researcher incorporated Benson's analytical scheme into each woman teacher's text, in order to reveal what the participants in the research study conceive of as biological knowledge; how that knowledge is made sense of; and how the participant's understanding of that knowledge is potentially transmitted during class lessons. Benson's guiding questions provide a focus by which the lesson presentations, observations and interviews could be interpreted (Benson, 1984, p. 98):

A. Pedagogic Perspectives:

1. What is the theme around which the teaching takes place?
2. What is the prevalent mode of teaching in the classroom?
3. What is the interest in the communication process?

B. Subject and Knowledge Perspectives:

1. What, according to the teacher's definition, constitutes Biology as an area of study?

2. What is the rationale for the teacher's knowledge?

Inherent in all these guiding questions are the teacher's pedagogical and knowledge perspectives, as reflected in the lesson material. Therefore, validated support from transcripts of teachers' lessons, interviews and the researcher's observation's of teacher/ student interactions are crucial.

If these questions are defined within a feminist framework of inquiry, as outlined in Chapters 2 and 3, then a gender-related analysis, which reveals women's experiences in the 'teaching of Science', can be authenticated. Benson's analytical scheme is a useful one in revealing women science teachers' 'texts' through assessment of their pedagogic perspectives and their subject (knowledge) perspectives. These 'texts' become the women science teachers' narratives. However, feminist critique requires a decoding of the text - an inversion of the narrative structure, to reveal underlying patriarchal orderings of knowledge, and in this sense, Benson, and Esland and Werners' schemes need to be critiqued and expanded.

A feminist analytical scheme must be employed in interpreting the social meaning of events and perspectives through description, and in relating the particular teaching events to theoretic considerations from feminist critique and philosophy. Specifically, then, theoretic questions considered in this study are:

1. What are the underlying intents and assumptions of the guiding question's subject and pedagogical perspectives? To what extent are these intents and assumptions part of the traditional patriarchal functional paradigm?

2. To what extent is the traditional patriarchal theoretical framework in science teaching internalized? To what extent is protest expressed or exhibited?
3. What teaching social relations are implied by cooptation of this patriarchal framework? What views of female students are implied?
4. What knowledge is selected and neglected? Who controls the dissemination of knowledge?

Research Procedures and Data Collection

Context of the Study: Validity and Reliability

A qualitative methodological approach has been cited in this study. In keeping with qualitative research orientations, the criteria upon which knowledge claims are to be judged, that is criteria concerning validity and reliability is interpreted as follows.

Validity

Validity as interpreted in qualitative research, rejects multiplicative corroboration; that is, repeated checking of the same phenomena over time, but rather, relies on varied checking of different sources of phenomena over time (Roberts, 1982). Validity according to Dawson, *Validity in Qualitative Inquiry* (1979), is interpreted to be the accuracy of a description as representative of a phenomenon. In the context of science teaching, if a descriptive representation of women teachers' 'ways of knowing' accurately represents the participants' understandings, then one can interpret 'legitimate knowledge claims' about these women's science teaching.

Varied checking of the same phenomena then relies upon a confirmation or disconfirmation by the teacher, of the researcher's varied sources of descriptions and interpretations of these understandings. These varied sources will be outlined.

Reliability

In qualitative research, reliability is closely connected to validity. Miles and Huberman (1984) suggest that in order to have a reliable verification of interpretations of phenomena; descriptive interpretations must accurately and consistently reflect the participants experiences in order to legitimate knowledge claims. In the context of science teaching then, if descriptive interpretations of the understandings of women science teachers are consistent according to the participant's various experiences, then one is reliable in interpreting the knowledge claims about these women's science teaching.

Study Pre-Entry

After an extensive literature review, it was decided that a schema of potential philosophical questions representing alternative epistemological views in scientific inquiry, could be established. A practical investigation arose out of a theoretical framework of philosophical investigation of differing philosophies in science and feminist views on the relation of science theory to practice. The discussion questions to be employed were designed within a framework to initiate discussion with a science teacher, with conversational exchange to be dialogic in nature.

It was decided that the research investigation should best exemplify a study whereby meaningful description and interpretation of events and phenomena could be the focus for inquiry. To provide meaning within a feminist epistemological

framework, probing for underlying theoretic bases in order to reveal tacitly held intentions and assumptions would reveal concerns relating to power relationships, and root metaphors of gender and politics in the classroom.

The researcher approached a University faculty member for a list of biology teachers who the faculty member thought would be receptive to participating in a research study. A proposal was submitted to the Edmonton Public School Board whereby a description of the research project, implementation design and ethical considerations to the co-operating organizations, were carefully outlined and approved. The principals of two selected large urban high schools were contacted and a meeting was set up to determine if a research project would interfere with the school's operation during a two-week period in the fall. Both principals accepted the grounds for research.

Originally in the research, four teachers were randomly selected from those teachers available in the two high schools. To accommodate the nature of the research questions, two female teachers were subsequently selected. This selection was based upon acceptance of terms of the study; length of stay in the classroom; and general teacher interest. Biology 30 was chosen as a subject area because the content lent itself well to elements of personal teacher commitment, sophistication of knowledge claims, interdisciplinary nature of content, and the potential for presenting conflicting theories. The departmental standardized achievement test offered at the end of the course, also raised questions of authority of text and curriculum, useful in such a study.

Entry Research

An ethnographic description of classroom interactions became the methodological orientation of the study. This description included the following sources of data: discussions between the researcher and each teacher, based upon informal open-ended questions; observations of each teacher's classroom lessons; two taped formal interview sessions between the researcher and each teacher; a journal or log of reflections by the researcher; and validated transcripts of lessons and interviews employed in the study.

Observations

As the researcher felt she did not want to be obtrusive to the continuity of the science lesson, she sat in the back of the classroom and for a two-week period, observed the classroom interactions, with each teacher. Observation sheets were employed (see Appendix A-1), which outlined minute by minute detail of all classroom proceedings and certain random lessons were audio-taped and later transcribed to provide a more detailed observation sheet, which could be used in the interpretation of the data (see Appendix A-2). All questions fielded by the teacher and entertained by students in the class, were recorded on observation sheets. In addition, a journal or log of reflective observations, and classroom dynamics, between teachers and students from an interpretive standpoint, was kept, daily. On some occasions, open-ended discussions ensued between the teacher and the researcher and these were recorded in the researcher's journal.

A summary of the numbers of students in each class, their gender, and the class seating arrangements appears in Appendix B. A summary observation sheet indicating the number of days observed, the Unit content observed, the types of

classroom activities engaged in by teachers and students, and all questions fielded in the Unit appears in Appendix C.

The Formal Interview

A further interview with participating teachers focused on the individual teacher's world views. These interviews were planned after the completion of a Unit and were approximately an hour in duration, although this varied with the individual teacher. The discussion was informal in nature, although a framework existed to initiate the discussion. Many questions arose from classroom events, therefore a dialectic or conversational exchange was pursued, in which the direction was not always wholly predetermined. All discussions were audio-taped and transcribed. The discussion questions focused around a number of themes:

1. Background and personal experience of the teacher
2. Conception of biology as a discipline
3. Philosophy of science as it relates to biological knowledge
4. Attitudes toward science and its relationship to biological knowledge
5. Emphasis on the curriculum on teaching (subject matter and pedagogy).

The questions were designed to allow the teachers to stress the pedagogic and content areas of their classroom practice which are affected by their epistemological view of science teaching, as suggested by this study's research design. The questions reflected what these teachers conceive of as biological knowledge, how that knowledge is made sense of, and how the teacher's understandings of that knowledge is potentially transmitted during lessons. A listing of specific discussional questions is found in Appendix D. Transcripts of the formal teacher interviews can be found in Appendix E.

Follow-up and Validation Procedures

At this point in the study, time was taken to transcribe the 'data' and to focus on methods of validation. Validations of teacher/student interactions in the classroom; certain observations made in my journal; reflective observations from open-ended discussions with teachers; and interpretations from formal teacher interviews were written up in the form of a letter, to each teacher. In a second interview session, these written observations and interpretations were discussed with each teacher, to further articulate and clarify the teacher's understandings, and provide insights into reasons for events included in the interpretations. Each of the teacher's comments were carefully recorded and a validated summary of these comments and interpretations were written up, including what revisions were deemed necessary. These are found in Appendix F. For Teacher A, a second validation was required. This validation can be found in Appendix G.

Analysis of Data

A research orientation was developed in this chapter which employs a feminist analytical schema. Feminist 'ways of knowing' incorporate ontological dimensions. In the context of teaching science - we cannot separate 'educational knowing' from knowing acquired through we/women's lived experiences, hence, in this analysis an effort is made to relate ontological dimensions of the two women teacher's conceptions of biological knowledge to their own lived experiences.

The two women science teachers' 'texts' have implications for the way that female students view biological knowledge and view science. Although this is expanded upon in the final chapter, an effort is made in this analysis, to expose the

lived and learned experiences of these women teachers in the processes by which their own scientific knowledge was conceived; hence the implications for the learning processes of young women in high school science courses, such as biology.

The following analysis and interpretation of the data follows the research design as outlined in the first section of this chapter and incorporates the observations and perceptions based upon the transcriptions of the teacher's lessons; validated transcripts of the researcher's observations; the formal interview; and informal discussions as well as personal notes kept in the daily journal, throughout the study. The presentation of the material follows the order of the guiding questions in the research design's analytical scheme. An individual analysis is made for each teacher. This constitutes each teacher's 'text'.

Owing to massive amounts of transcribed material, a complete transcription of all the classrooms lessons for each teacher is not included in Appendix A-2. A complete transcription of the formal interviews, as well as transcriptions of the validated understandings of teacher and researcher, for both teachers, however are found in Appendices E, F and G respectively. The following symbols are included in the analyses and interpretations in Chapter 5 which follows, as well as in the Appendices:

♂	Male
♀	Female
. . .	Conversation fades to a stop or restarts on another theme
L:	Teacher - Lillian*
B:	Teacher - Brenda*
I:	Researcher
S:	Unidentified student
(s):	Identified student (see Appendix A-2)

* pseudonyms have been chosen to maintain the anonymity of the teachers.

Ethical Considerations

The two women teachers participating in this study, did so on a voluntary basis. Parents of the students were informed of the nature of the research and anonymity of the participants and schools in this research study is respected. Therefore certain revealing particulars of each teacher have been slightly modified to respect their anonymity; this does not affect the validity of the knowledge claims of the study.

CHAPTER 5

WOMEN TEACHER'S CONCEPTIONS OF SCIENTIFIC KNOWLEDGE

Introduction

This chapter is an analysis of two women teachers' 'ways of knowing' about Biology, as a scientific discipline. As stated in the last chapter, feminist 'ways of knowing' incorporate ontological dimensions. In the context of relating these two women teachers' conceptions of scientific knowledge to their own lived experience, it is significant to introduce each teacher to the reader.

Introduction of Teacher Participant: Lillian

Lillian is in her eleventh year with the school board, but has about seven and a half years of full-time teaching since she has been part-time throughout her service. Lillian has taught biology at all levels in the high school curriculum and has also taught Science 11. She has an undergraduate degree in Education with a major in General Science. Lillian also has a minor in Ukrainian and spends some of her free time working for Alberta Education, evaluating the content of textual material in relation to tolerance of ethnic cultures. Lillian would like to go back and finish a BSc in order to augment her knowledge of Chemistry and Physics. She states that, "there are some key areas right now that I'm really keenly interested in . . . Biochemistry . . . I'd really like to go into that field and take another course and get into it a little bit more." At present, Lillian has no interest in pursuing administrative education.

Lillian is a modern, attractive woman with a very casual style which students respond to. Lillian dresses in modern, yet casual clothing with a sporty look. Lillian is very interested in health-related issues and nutrition, and incorporates these issues into her classroom dialogue. Lillian's husband is in the medical profession and Lillian attributes much of her interest in health care to her husband's interests, and talks a lot about him and her family, both in and out of class. Lillian has several children and is very interested in child development and the relationship of scientific issues to her children's development. Lillian is environmentally conscious and is very interested in the relationship of science to society.

Lillian does not consider herself "a feminist". She acknowledges that she has always been more interested in what have been traditionally men's fields of study (like science), because she found them more interesting. Lillian believes she reflects her father's characteristics; she attributes her sense of humour to her father. She states, "I've always preferred to be around men. I grew up with sisters and now I'm married and we have sons. I prefer that . . . boys are not as temperamental . . ." Lillian feels that her male colleagues have more control and more authority in the classroom, but is not exactly sure why.

Introduction to Teacher Participant: Br nda

Brenda has taught 10 years - seven years at the junior high school level and three years at the senior high school level. Brenda has an undergraduate degree in Education with a major in Biological Sciences. She also has a double minor in French and German. She has taught Grade 7 Science, Biology at all high school curriculum levels, as well as Chemistry 20, French 20, and an ESL class. Brenda is

very happy with her education currently and indicates no interest to pursue administrative or other course work. She does mention that, "I wouldn't mind getting eventually into some more Chemistry, maybe . . . and I suppose it wouldn't hurt to get some more Physics . . . somewhere along the line."

Brenda is a very modern and attractive woman, in her personal appearance. At the time of this research study, she is pregnant. She wears maternity clothing but makes no mention of her personal appearance to the class. Brenda does not discuss her husband and there is no mention of his interests or his influences on her, either in or out of class. She has no other children. During the course of the research study, Brenda did not discuss her pregnancy in relation to any aspect of subject content matter in anatomy. Brenda is interested in societal issues and uses her knowledge to augment her content material, however she did not discuss societal issues in class, during the course of the research study.

Brenda does not consider herself a "feminist", however she is very interested in feminist issues and participates in the WISEST[1] programme, which encourages more high school girls to pursue scientific careers at the post-secondary level. Her participation is that of recruitment and encouragement of young girls, rather than an active involvement in WISEST at the University of Alberta.

Brenda does not discuss her family at all and perceives her interests in science and education to be related to her interests in society and people. She does not perceive her male colleagues to have any more control or authority, in the classroom, than she herself has.

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[1] WISEST - Women In Scholarship, Engineering, Science and Technology.

Analysis and Interpretation

Text of Teacher: Lillian

1. What is the theme around which the teaching takes place?

Lillian chose to follow the curriculum requisites, as outlined in *Curriculum Guide by Alberta Education* (1984), as her set of themes for teaching the unit on Excretion. The themes which are set out in the Alberta Curriculum Guide are mechanistic[2] in nature, in that their theoretical foci raise questions concerned with cause, function, 'link with', or 'influence on'.

Lillian organized her topics according to a 'structure/function' organizational pattern and each day her intent was to present a collection of specific informational statements which were written onto an overhead and translated to the students. These informational statements related anatomical kidney structure to overall physiological function, in Excretion. Content came from the requisite text; a University reference source book and information was selected from these according to curriculum dictates and potential departmental examination questions which would reflect specific informational components.

For example, on Day 3 of the study, Lillian started the class with an overhead chart which outlined the concentrations of ions and molecules found in blood, plasma filtrate and urine. After the students had some time to copy this chart down, Lillian mentioned that this chart had been on a departmental exam and that she would ask some potential exam questions:

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[2] See definitions for mechanistic, scientistic understandings in Chapters 2 and 3.

L: I think that you can list three differentiating factors about this chart. [pause] Has anyone thought about this? Have you written this down yet? [pause] There are some obvious conclusions here. When you draw a conclusion you have to have some knowledge to base it on and we're a little limited in our knowledge right now. What is plasma?

S: Uh, blood . . . blood minus cells and stuff.

L: Yes, that's right. Where is the blood in the kidney found? [pause] It is found in the renal artery. What is filtrate? [pause] Well, filtrate has the same concentration of dissolved substances as blood plasma, just as predicted. So what differentiates them? [them refers to blood and filtrate, however since it could also refer to blood plasma, some confusion results]. Can you draw any conclusions from the chart?

S: No.

L: Right then. What conclusions can we draw? [points to a Student]

S: Blood plasma and filtrate are the same. [In fact, this is true, but evidently not the answer that Lillian was looking for].

L: No, we're not hitting the nail on the head, yet. This is a good exam question.

S: Large protein molecules can't be filtered through so blood is different. [Student has perceived the actual question being asked and has responded correctly].

The basis upon which Lillian accepts or rejects knowledge is prescribed. The chart dictates a mechanistic understanding of kidney function and Lillian's questions directly reflect the 'link with'; i.e. link between blood and filtrate in kidney function. The questions are predetermined; i.e. their determination prescribed by departmental exams. Conclusions are based upon prescribed knowledge although the knowledge is verified according to what was predicted, experimentally. The basis upon which knowledge is accepted or rejected is therefore empirical.

Although the conceptual themes around which the science teaching took place were mechanistic in their nature, there were often contradictions as to the

importance or significance given to these themes. On the one hand, although the importance of understanding the conceptual information in the Excretion unit, because of departmental evaluations was expressed; on the other hand, there were daily discussions about the relevance of this information in the lived experiences of both the teacher and students.

For example, on Day 4 of the study, Lillian started the class by teaching about the role of the liver in Excretion. This led to a discussion about the effects of alcohol on kidney function and the homeostatic mechanisms that the body uses to adjust water loss. The discussion quickly led to an off topic issue: AIDS:

S: What if you knew one of us had AIDS. Would you let him in your class?

L: O.K. We'll talk about AIDS in the reproduction unit.

S: Hey, Can they accurately test for AIDS? I read something about . . .

S: What causes AIDS?

L: It is caused by a virus.

S: What if you knew one of us had AIDS? Would you . . .

L: The way I live my life, I would not be worried about getting AIDS. I can't kick a student out for having AIDS.

S: Why do gays get AIDS?

L: Uh, You know, I don't know much about that. [pause] I'll bet you know more about that than I do. You know, this is not a problem for intelligent people to deal with this. If you know better, understand the facts, live healthy . . . you won't get AIDS. How about abstaining from sex until you are married?

S: That's old-fashioned!

L: That may be old-fashioned but it would sure cut down on AIDS!

S: I disagree. I think anyone can get it.

L: Well, this is a societal problem.

This discussion ensued for 20 minutes, with students inquiring about factual data on AIDS; ethical positions and ultimately, Lillian's position on all of it. Lillian allowed the discussion to proceed, however became frustrated several times because students questioned her stance on moral values.

L: You guys are concerned about AIDS . . . why? [Note, at the time of this research study, AIDS was not yet incorporated into the curriculum as a scientific issue, nor had the new occupational skills and family-planning course been incorporated into the high school curriculum.]

S: There's a chance that AIDS could kill the whole population.

L: Well . . . if you abstain from sex until you are married . . .

S: What if you don't know and you marry the person?

L: Have an AIDS test and if it is negative [the test] you can go on with the marriage.

S: But you can do that and not be married . . .

S: I don't think that the emotional strain of having to go through an AIDS test is good for marriage . . .

S: I'm never getting married . . .

L: Oh, I think you should just be careful about who you marry and stay faithful to that person and you won't get AIDS.

S: I think you should be careful and you don't have to be married . . .

Lillian insisted that if you live your life in a moral fashion; i.e. you were monogamous to your spouse - then you would not contract AIDS. This led the students to question whether one needed to be married and whether premarital sex was O.K.

Lillian's mechanistic understandings of the nature of science, as conveyed in a structural/functional sense on the workings of the kidney were inadequate at this point to deal with student inquiries. Lillian relied on her individual socialization in sociocultural values to convey to her class that AIDS could be prevented through monogamy. But there was confusion as to the relevance of her sociocultural values in relation to the student's values. Although she was often frustrated, she allowed the conversation to proceed. She took a clear stance with the class as to her understanding of the ethical issues involved with AIDS and it was only the school bell which, when it rang, interrupted the heated discussion.

In her class, Lillian was clear about whether feelings or values should play a role in societal decisions. However, when pressed on this issue, in the formal interview, Lillian was ambiguous. She wasn't sure whether values or feelings should play a role in societal decisions about scientific issues.

I: Well, do you think that feelings or emotions should play a part in the kind of research that [scientists] do?

L: They shouldn't but I think they do . . .

I: Yes?

L: I think they do have a factor in how decisions are made.

I: You said you think they shouldn't . . . is that because you feel science should be objective?

L: Yes . . . I think it should be fairly objective . . . Yes.

I: And do you think that feelings or emotions should play a part in making societal decisions about science?

L: Again, I think no, but I think they do come into play - that's why we have certain issues that are so controversial which take feelings into play.

In fact, Lillian incorporated a personal knowledge into her understanding of the AIDS issue with her students, in discussion; however when asked to reflect upon it, she wasn't sure it represented scientific teaching.

Lillian often incorporated contextual societal issues into her daily class - with ambiguity. She enjoyed discussions and stated so in the formal interview, however, the discussions were often dichotomized practically, from the theoretical nature of the lesson material conveyed to students on a given day. Hence, students were led to believe that ethical discussions were not a part of science - they were just fun. And often, they took up a great deal of class time. One can think of a number of reasons why students would engage Lillian in the variety of discussions which took place over the study.

In summary, a mechanistic understanding of scientific knowledge was conveyed to students as a legitimate theme - legitimate knowledge. Contextual understandings were seen as problematic. Clearly they were important, interesting and fun, but were not legitimized in the sense of 'empirical truth'. Students were led to an ambiguous understanding about the relationship of science to society, to themselves.

2. What is the prevalent mode of teaching that occurs in the classroom?

Lillian spent very little time actually giving notes (see Appendix C). She introduced each consecutive class with an overhead informational sheet and sheets were displayed periodically throughout the classes, however, she preferred a conversational approach to the class. She often engaged the students in dialogue. In fact, it was never completely evaluated by Lillian, as to whether any of the class members actually wrote any of the information down, however it was noted by the

researcher that few students copied all of the information down, over the course of the study. She would occasionally ask if they had written the information down, but periods between overheads were often short, so that it would be difficult for students to get all the data. However, students never questioned whether they should be taking any or all of the information down.

Much of the conceptual unit information presented to the students was teacher-guided through a 'direct-questioning' approach. Lillian directed questions to her students and she then fashioned their responses according to her knowledge. According to the data in Appendix C, Lillian directed 177 questions to her students over the course of the study. Of these, 91 were answered by students. The students instigated a total number of 143 questions to Lillian, 83 of which were off-topic.

Lillian prompted students' responses with reference to potential departmental examination questions and in one of the interviews stated, "Students respond more to a departmental exam - the external factor is important. It's the objectivity factor - students can't gauge, you know, they must know the stuff." In another interview, Lillian stated,

> . . . I like that students take it more seriously with a standardized exam. Otherwise I don't think they'd take the course seriously. They'd try and get by with a little less work. With the diploma exam, it's like it's someone else handling it at the end of the year, and that external person they don't know about, I think it puts a little more scare in them.

Overall, students were given the impression that the information on Excretion was important because the departmental exam was important.

Lillian spent a fifth of her class time, over the course of this study, on management disruption (see Appendices B and C). This refers to episodes of interrupted teacher control over classroom activities. In particular, a group of boys (see Appendix A-2), instigated problematic situations for Lillian, which were often humorous, mostly interruptive, but not seriously delinquent. In particular, a Canadian/Asian student [identified student in the text: (s)] is the instigator of the majority of the incidents.

For example on Day 3 of the study, Lillian discusses the composition of urine:

L: O.K. We're talking about the composition of urine. [pause]

(s): I saw this guy doing three or four pelvic thrusts.

L: What does this have to do with urine?

S: Hey, can those strips which we did in the lab also tell if you're pregnant? [Student is referring to a lab which the students did, in which the glucose level in the urine is measured by a pretreated chemical strip . . . this leads Lillian off topic].

L: Yes.

S: Remember that Mash show where Radar needed the rabbit for a pregnancy test?

(s): You mean he got the rabbit pregnant?

L: Student (s), I think you'll have to leave the classroom, your mind is in the gutter.

This leads to a discussion for a brief period, about how one becomes pregnant. Lillian manages to finally focus the discussion back onto the original theme, by asking about how glucose gets into the urine.

On another occasion, on Day 6, Student (s) comes into class late and loudly comments how nice Lillian looks today. All of the students are writing a quiz and his comment falls on a quiet room. He sits down and requests that someone in the class give him a pen to write with:

(s): I lack a writing utensil.

L: You lack more than that Student (s). [laughter]

S: Here's a pen.

(s): Hey, anyone want to see my art. [He displays a drawing from an art class, for the class to observe, but nobody comments. Student (s) writes the quiz and is the first to walk to the front of the class and return the paper to Lillian]. How did I do?

L: As usual, you could do better. [Student (s) does well academically in Biology 30, so the inferences behind this remark are meant to control his current interruptive behaviour].

Lillian frequently deals with male student's interruptive behaviour that connotes sexual innuendos. Lillian attempts to dilute the interruptive behaviour by redirecting the student's thoughts or actions through humour or by involving other class members to apply pressure to the instigator, although she is not always successful. When questioned about this in the interview, Lillian stated: "I think humour is the spice of life and I like to humour them. I like to be friendly but firm, being authoritarian isn't important to me. I reflect my Dad's characteristics, you know; he had a great sense of humour."

In fact, Lillian was a very modern, attractive teacher (see Introduction); casual with a personal style that the researcher perceived students liked. She used this style to let students know she was human and that they could relate to her. In

her teaching pedagogy, Lillian also used a casual conversational style of dialogue. This was problematic for her. This led to challenges by male students in relation to her teacher authority . . . which quickly led to challenges in relation to her authority of knowledge. Lillian consistently fell back on her status of an external authority factor - the departmental exams - to remind students' of their position in the teacher/student hierarchy; i.e. the student had to write the exam, not the teacher. When Lillian's authority of knowledge was challenged by male students, as in the discussional incident on the topic of AIDS, she retreated from a value position to an empirical position and focused on the factual data which could support her claims.

L: Well now, let's discuss where one contacts the AIDS virus.

S: I heard you can get it in a jacuzzi.

L: Well . . . statistically you cannot get it in a swimming pool; and besides the chlorine would kill the virus. The high temperature of the jacuzzi would . . .

S: Are you sure about that?

S: Yeah, I heard it's even in saliva.

Although there was sometimes ambiguity in Lillian's and the students' assessments of which of her facts were 'theoretically empirically verifiable' and which were 'practical position statements', when her theoretical epistemological framework was a mechanistic one, she was not questioned by the male students any further.

3. Interest in the communication process

Lillian discussed the influence of her husband's career on her teaching, in the final interviews. She indicated that because her husband was in the medical

profession she felt very strongly about health-related issues guiding both her personal and professional life.

L: . . . my husband is a medical practitioner. So I'm interested in human biology, in general. He specialized in that area - he has a lot of knowledge about the human body. He has to deal with situations that, actually are more extensive than people realize. You can have a number of situations occurring in a office and you have to be very informed of everything . . . CPR courses . . . he has to have a medical every year and keep his health up to par. He's very health conscious, so I'm more sold that way than I probably would have been, had I not known him. And I have a personal interest in human health, because I basically have been fairly lucky healthwise - but I now reflect upon the fact that my parents didn't have the good health they could have in their latter years. And I think back and try and think of factors that may have contributed to that. I'm interested in living a long time - as everybody is.

I: So you find that, in a sense, science does affect your personal life.

L: Yes, a lot of things I do and talk about in class, are things that I personally believe in and have read a lot about. I try to keep up on all of the new things that are coming out and I do quite a bit of reading. Magazines and newspapers . . .

Indeed, Lillian incorporated her personal lived experiences into her teaching in each class which the researcher observed, over the study. Her discussions, although often off topic, incorporated health-related issues and she would frequently interject a position comment about a conceptual statement which she was teaching, that came from a current newspaper or magazines.

There was an apparent conflict between what Lillian felt was 'professional' teaching and what she would like to teach. She states:

L: I feel people will judge me if I bring my personal life style into it . . . I don't want to . . . but students find out anyway and they're interested. But I like to keep my distances, you know . . .

When pressed on this issue, Lillian, states:

> I have flashes, you know, sometimes, feeling unprofessional, but then, I think, when I see student's benefitting from the conversation . . . I benefit from it. I would put in interesting health-related issues, if I could. Side-issues, you know, to motivate them! I would like to zero in on topics relevant to them and their life and living in harmony . . . healthy . . . But because of diploma exams, nothing like that could be tested . . . so I hesitate . . .

Although Lillian attempts to control communication by initially setting out with a traditional pedagogical style with traditional content, her interest in health-related side-issues often become a topic of discussion in class. The contextual nature of these issues often encourages student-initiated questions which she is obliged to respond to and she, as a result no longer controls the discussion. In the interviews, Lillian comments that she would like the students to enjoy learning and that this [the content] is just a stepping stone to future interests in science. However, there is ambiguity in her understandings, in that she acknowledges that the students won't take things seriously, without a departmental exam as an evaluative factor.

Lillian directed more questions to boys and more boys responded to her generally fielded questions. More boys also initiated questions to her (see Appendix C). In the interviews, Lillian states:

> I know that I ask more boys questions, now. I don't know why. Well, boys have more interest in academic things. My interest in science started with an interest in things that boys were interested in . . . they had higher goals. They were always more interesting than girl's things, boys were not as temperamental . . .

But when asked about the lab and students' response to a dissection of a kidney, Lillian responded:

> Well, you know, it's just a peer thing . . . reacting unthinking . . . as soon as they get into the job, it's just the opposite! Big 200 lb. macho jocks can't handle it and the gals think it's interesting!

Lillian goes on to suggest that probably girls are more self-conscious and less apt to ask 'stupid questions' because they are also more mature than the boys. However Lillian felt that more boys were interested in science and biology.

In one classroom incident on Day 3 of the study, Lillian questioned a male student about his note-taking:

L: Are you writing notes, Student A? [she looks at the girl, Student B, across from him] or do you have a secretary writing for you? [directs her comment to Student B]. I must talk to you!

S: I take notes for the group [referring to the group of three boys - see Appendix B for position of the boys in relation to management disruption]. You can't learn everything while you're talking and writing at the same time.

L: Is that what they told you. I see. So boys, you can't listen to me talk and write at the same time? Can you chew gum and think at the same time? [laughter].

Although Lillian chides the male students for their sexist behaviour she consistently responds to their demands more frequently. In part, this is because fewer girls make demands of her attentions. However, Lillian elicits fewer questions from the female students in the class and when pressed on the reasons for this discongruity, she believes that boys are inherently more interested in science and biology, and that girls are more mature about their behaviour.

4. <u>What, according to the teacher's definition, constitutes biology as an area of study</u>?

In this analysis the teacher's understandings of content is interpreted to be the view of biology that provides the themes around which the teaching takes place.

Lillian perceived biology to be about living things. When asked how she perceived biology to be different from the other sciences, Lillian explained that Biology is more personal and more readily applicable to everyday things that we do. When she hesitated and realized that chemistry or physics could also apply to everyday things . . . she simply responded that: "there seems to be more down to earth information in biology, than in physics."

The researcher asked Lillian to elaborate on how she thought biology was personal:

L: Well biology enables us to understand more and more about ourselves and society as a whole. If affects us in many ways, because there are so many diseases and disorders and things that are happening in our society. Biology is a means of learning about these things and possibly changing them or doing something about them.

Lillian was very clear in suggesting that biology incorporated societal and technological issues, however she became ambiguous when asked about whether she thought scientists incorporated emotional value judgements in their work:

I: Alright, well do you think that scientists can be emotional or have feelings about their work?

L: I'm not sure about that.

I: Well, do you think that biology is a more 'feeling' science than chemistry or physics?

L: Oh yes, I think so.

I: Well, do you think that those feelings or emotions should play a part in the kind of research that scientists do?

L: They shouldn't but I think they do. . . .

I: Yes?

L: I think they do have a factor in how decisions are made.

I: You said you think they shouldn't . . . is that because you feel science should be objective?

L: Yes . . . I think it should be fairly objective. Yes.

When asked about the pilot STS[1] curriculum which was being prepared at this time, Lillian had ambivalent feelings. She wasn't prepared to say whether it would be positive or negative but simply responded that: "we'll have to wait and see."

In fact, Lillian suggested in several interviews as well as in informal discussions and in her classroom pedagogy, that societal issues - health-related issues - were significant themes to focus on. Classroom discussion was a significant pedagogical occurrence. Although Lillian felt that theoretically science should be objective, she often offered practical value positions in her classroom. This was an inherent part of Lillian's understandings of biology, which she communicated to her students, although which knowledge was legitimated was often ambiguous. However when asked in a formal setting to speculate on this theoretically, Lillian wasn't sure whether value positions belonged in Science.

5. What is the rationale for the teacher's knowledge?

This analysis involves the teacher's view of the world, her epistemological positions and conceptions of science. Lillian has a particular understanding of the scientific method:

I: And what is the scientific method to you?

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[1] STS - Science Technology and Society.

L: Inquiry method - where you are asking questions about some particular thing. You are hypothesizing as to what you think might occur and then you do some sort of procedure at some point - get the results, interpret the results.

I: Alright, what then is objectivity?

L: Being objective - not being influenced by pre-conceived notions.

I: Do you think that science is objective?

L: Should be. I don't know if it is or not.

I: What makes you doubt that it might not be?

L: I'm thinking about all the things that are written in texts. From my experience, especially with this work I'm doing, all this knowledge that has been put into books. It's sort of maybe limiting us - or maybe we don't want to know if other things are occurring or if they are actually happening.

Lillian is referring to a contract which at the time of the research study, she engaged in with Alberta Education, whereby she examines texts and materials for content which would be intolerant to various ethnic cultures. She explains that this is related to her cultural heritage as a Ukrainian and that she has been asked to review some Ukrainian materials coming out of the Soviet Union for underlying racial biases which as she explains it, "are not acceptable for our educational philosophy in Alberta." In this sense, Lillian is aware of the existence of 'pre-conceived notions', yet when asked to apply this concept to scientific knowledge, she isn't sure whether science is influenced or not. When the researcher asked Lillian about scientific truth and absolutes, Lillian responded that there are laws that have been proven through experimentation and the results are verifiably consistent, therefore they are 'true':

I: Do you think that science can define absolutes?

L: Yes.

I: Do you think that science can verify the truthfulness of something?

L: Yes.

I: Does science have any limits to its own knowledge?

L: No.

Lillian's rationale for her understanding of science lies in a mechanistic understanding of the nature of science. Knowledge is verifiable and logical procedures are taken to arrive at 'truth'. Epistemologically this understanding is part of logical positivism. The only valid kind of knowledge is scientific.

Lillian brings ontological dimensions into her understandings however, which make this analysis a much more complicated one. In the final interview, she discusses her early learning experiences as a student in physics, a subject in which she was initially interested and then dropped because she lost her interest:

> L: I had difficulty with the Profs. I found the classes more interesting in biology because I could understand the Profs. better. I had difficulty in physics - there was a language barrier. I think that contributed to my turn-off in physics. I don't know. I guess - well, you know, I had two children while I was in university - and you know anything that I took in biology related to my kids a bit. Whereas physics was not related to my family life . . .

Lillian went on to discuss the impact which the genetics professor had on her unborn child at the time:

> L: It was during the summer and I was seven months pregnant and the Prof. gave me - I don't know - he made me feel a part of the class. He felt that I was the one who would really want to know about all that genetic information - because it really applied to me . . .

There is a 'personal' knowledge which Lillian incorporates into her understandings of biology - based upon her 'intuitive' feelings, her personal feelings about bearing children. This is reflected again in her comments about the influence of her husband's profession on her "being health-conscious" and also in statements made in the final interview about her concern about her parents' loss of health.

There is a dualism here between Lillian's intuitive understandings inclusive in a contextualist world view, and her perception of the natural world which exists in reality, that is, perceptions of the world which come through sense experience. This is further defined as empirical: i.e. the scientific method is seen as the process through which natural characteristics are established as knowledge. It is not surprising that these two epistemological frameworks of scientific knowledge were often ambiguously presented in class and seemingly, to the students, at odds with each other. One set of understandings were legitimated over the other. Indeed, Lillian was often confused over which set of knowledge structures were legitimate. She often relied on her learned understandings of science and when challenged, chose a mechanistic view as her legitimate authority.

Text of Teacher: Brenda

1. What is the theme around which the teaching takes place?

Brenda's themes for the unit on the Circulatory System - were based upon curriculum requisites, exactly as written in the *Curriculum Guide by Alberta Education* (1984). In fact, even all of the Curriculum Guide's suggested elective topics were mentioned or discussed at some point, throughout the course of this study. Brenda's understanding of the basic content was organized within a very

specific framework of headings and sub-headings. On Day 1 of the study, after delineating the number of weeks the unit would take; the weighting of the unit, overall in the course; the day of the unit exam, Brenda placed an overhead layout on the screen which broke the unit down into its components.

B: You will notice the objectives of this unit clearly outlined and I will be giving you notes in each lecture which you should copy down. Later in the unit I will give you a small research question and expect you to report back to me. Then I will be giving more notes. You will notice that I am doing the unit in reverse - from your text - because I prefer the organization of the material that way. Any questions so far? [No questions].

Brenda clearly divided her unit into sub-headings, according to the Curriculum Guide, and the unit was presented as a collection of specific informational facts translated to the students according to Brenda's knowledge of her subject This knowledge was up-to-date according to curriculum standards and the lecture material was augmented with material from the requisite text; science magazine articles; conferences, and reference material from first year University Biology texts. For example, on Day 4 of the course study, Brenda read the class an article on artificial hearts from *Science World* and then stated:

B: I attended a symposium at the Convention Centre, on current information on blood and circulation which was hosted by the Red Cross Association. I saw the computer model, used at the U. of A., to train medical students on heart attacks.

Brenda proceeded to explain how these models were used and later stated in an informal discussion, that she incorporated the material from this conference into her lecture notes. In fact, her lecture notes were clearly organized according to headings and sub-headings exactly as curriculum specifications would indicate, but

the level of detail in these notes was slightly more than what curriculum mandates require.

Brenda incorporated a mechanistic understanding of her subject matter into the themes around which her teaching took place. Content was presented as a collection of facts, verifiable through experimentation. There is a strict commitment to a fact/value dichotomy, with strong legitimation of empirical knowledge. Brenda's empiricist epistemology posits a historicist[4] conception of the inevitability of scientifically mediated progress; i.e. the tendency to view a progression towards an ever more complete knowledge of nature through elaborated techniques such as controlled experimentation, the use of scientific quantitative techniques and verification.

For example, Brenda, on Day 5 of the study, began to teach systemic circulation. An overhead transparency with point-by-point information on systemic circulation was turned on to the screen.

B: O.K., any questions on heart and pulmonary circulation before we move on to systemic? [No questions]. Now we could spend more time on this, but I'm not giving you too much, because the departmental exam never asks too many questions on this, so there is no use memorizing a lot of terms. O.K. Oxygenated blood passes through the left side of the heart and out the dorsal aorta to distribute oxygen and nutrients to individual cells and to collect metabolic wastes. There is higher pressure in systemic circulation. Systemic circulation is divided into two categories: coronary and renal circulation. Do you know why they don't take blood from any of the arteries in the renal circulatory system? [No responses]. It's because this is the purest blood. Lab technicians want a typical blood sample and so they take their samples from areas other than filtrated circulation. Also it's a dangerous area to extract blood from. We know this because of the many experiments that have been done and of course, our technology now is so advanced. We can even

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[4] See definition of historicist conception of the inevitability of scientifically mediated progress as defined by the *Dictionary of the History of Science* (1984), in Chapter 2.

determine where the best place to extract blood from the body is! Any questions? [No questions].

Brenda legitimates her empirical knowledge with this historicist understanding of the inevitability of scientifically mediated progress, and there are no student questions to challenge this claim. Although Brenda's understandings rely on mechanistic understanding of science, there is also a normative view which she uses to select her content themes. On Day 4 of the study, Brenda discusses circulation in the heart, and again states:

B: Now we could spend months on this topic alone, but I'm only going to give you the essentials because the departmental exam asks very specific questions. There's no use memorizing a lot of terms. I'll give you the important ones.

Brenda interprets what is significant knowledge for the student according to normative standards; that is, the knowledge selection based upon what is the norm as dictated by the departmental exam. She is also conscious of standards that her students must achieve and is concerned that students meet these standards. In the final interview, Brenda states:

B: They [the school administrators] are more concerned with the outcome . . . how many honours on the departmental . . . but then they're getting that pushed on them too from higher up. You know I get very concerned if students are learning everything.

Brenda also states in another interview that she can't fall behind in her classes. She compares her pace to other biology teachers and states: "I couldn't be a week and a half behind in a unit or I'd never finish!" Indeed each class is carefully paced

and sequenced so that the allotted material is covered, according to her time schedule.

In contrast, Lillian addresses similar content themes but she presents them through concepts of structure and function - her approach is less theoretical and less detailed. Lillian incorporates normative standards into her teaching themes, in that content is often selected according to the norm dictated by the departmental exam. However, it is not a priority for Lillian to be standardizing her students' achievements according to other classes in the school nor does she keep track of the sequential pacing of subject material with other classes, like Brenda.

In summary, Brenda's mechanistic understanding of scientific knowledge is conveyed to students as a legitimate theme - legitimate knowledge. A normative theme is also incorporated into her teaching and relayed to students as significant in terms of selecting content - that is, knowledge selection. Brenda did not engage in extensive discussions in her class, over the course of the researcher's study. Contextual understandings of the relationship of science to society or to the individual are clearly demarcated by a fact/value dichotomy. Opinions in her class were always stated as such. In contrast, the legitimacy of Lillian's contextual understandings in her teaching were often ambiguous, leading to student's ambiguity in deciding on the legitimacy of the knowledge being presented to them.

2. What is the prevalent mode of teaching that occurs in the classroom?

Brenda used a direct lecture pedagogical style. She presented a section of information, in overhead note form, explained it to the students - statement by statement, and then allowed the students time to copy the notes down. She specifically asked them not to take notes while she was talking; that they would have

time at the end to do so. She consistently gave the students ten minutes to take notes down afterwards, depending on the length of the overheads. She consistently made sure all students were copying the notes. This pedagogical style was not deviated from over the course of the researcher's study.

There were very few questions directed to the class or to specific students (see Appendix C) and fewer questions were initiated by students in response. On either side of the desk, questions initiated were clarifying or elaborative in nature. In this sense, there was absolutely no challenge to the knowledge presentation of Brenda, by the students. When Brenda answered a student's question, she answered it according to her understanding of the knowledge of the subject matter but frequently used an authoritative phrase, such as "Yes, I read in *Science World* that . . ." which legitimated her knowledge as being other than her own.

In the section on 'Blood Components', in the unit on Circulation, Brenda had the students research and write up their own notes for this particular part. Upon introducing this section, she stated:

B: I'll give you the information you need to research. I'll highlight the key ideas you need to know and then, you'll appreciate my own note-giving!

The above incident is an illustration of Brenda's control over student input by placing limits on what is appropriate content to research and what is not. This understanding carries over into her lack of discussion in class. Brenda spent 16 minutes over the course of the research study on discussion. The longest in-class discussion was seven minutes. This is certainly in contrast to Lillian, in whose class a discussion could reach a maximum of 40 minutes in length. When asked in the interview about classroom discussions and their efficacy, Brenda states:

B: . . . there's always some time for that! It's not that you know, you just have to stay strictly with the facts, there's always time for discussion.

I: . . . so if a student were to instigate a question that was slightly off your topic, that had to do with biology, would you pursue it?

B: Hmmmmm . . . Yes.

In fact, Brenda never answered a student's question which was off topic, over the course of the researcher's study, because a student never asked a question off topic. Brenda places control over student input by placing limits on what is appropriate to discuss and what is not. This is an unwritten rule in the classroom and students observe it. This is an interesting deviation from Lillian's pedagogical style.

There is almost no management disruption in Brenda's class. The very little that does occur is always at the beginning and end of the class, whereupon Brenda takes a few minutes to settle students down. On the last day of the research study, students were to copy notes down at the end of the class from an overhead transparency. Students were talking and Brenda stated:

B: Ladies and gentlemen we are note-taking. You can visit on your own time - not my class time!

The students immediately settled down. Brenda's teaching style was not challenged, by the students during the research period. Hence, she as a teacher, was not problematic for students. She represented a teaching style which they were most familiar with. Indeed her pedagogical style typified a traditional and 'masculine' one, with the relationship between teacher and student dichotomized authoritatively.

3. Interest in the communication process

Brenda discussed her goal-orientation as a student; her interest in the life sciences and her interest in people as influential reasons for her position as a biology teacher, in a large urban high school. When asked about her motivation to pursue biology, she responded:

B: I was always really interested in the life sciences . . . I found them really interesting . . . I started off with your basic 100 level biology and enjoyed it and decided to make that my major.

I: O.K. Your interest in the life sciences motivated you to go on and do a degree in biology? What about the teaching aspect?

B: Oh . . . I don't know . . . it's just something I wanted to do for years . . .

I: So you always wanted to be a teacher?

B: Yes.

Later in the interview, she states:

B: The life sciences sounded very interesting. I wanted to teach. I wanted a job where I would be dealing with people. I thought it would be an interesting subject to teach. Especially Biology 30 - the human physiology.

I: O.K. Why Biology 30?

B: It relates to how the body functions. And I like genetics.

The conversation continued to reveal that Brenda was pregnant at the time and that she found Biology more relevant as she anticipated her yet unborn child:

B: I have more relevant facts [now], floating around in the Reproduction unit because I'm doing more reading.

Although Brenda was motivated to become a biology teacher because of internal, personal factors, this was never communicated to the students, over the course of the research study. She maintained a strict fact/value dichotomy within her teaching style. Indeed, Brenda mentions that "she has more facts floating around," because of her sparked interest in Reproduction and she communicates to students that facts are legitimate units of scientific knowledge. Brenda's interest in the communication process is as 'the expert', who transmits factual statements about biological knowledge to her students. As an expert she controls the communication process. The students are clearly ignorant of their subject matter and the purpose of communicating to the student is to improve their subject understanding.

When Brenda was asked about what attitudes she would most like to impart to her students about science, she responded:

B: I'd hope that they'd just develop an interest in it and know that it's something that they can do life-long. You know, go on and take courses at the University . . .

There is ambiguity in the notion of self-motivated interest which students would carry with them, to further their education in science, and their past experience in dissemination of scientific knowledge as transmission from expert to non-expert. Unless the student is motivated, as a non-expert, to learn more - there is no apparent variable or factor which would encourage the student to find meaning in biology.

As already stated, Brenda relies heavily on departmental standards to guide the communication process. She is very conscientious about her students learning all the material and states in the interview:

B: . . . You know I get very concerned if students are learning everything. I have been taking this teacher effectiveness programme, but unfortunately there is not a way to ensure every kid is learning. That's because there are too many kids. You start out in Biology 10 with a ceiling - 35 students . . . how can I deal with each student and all my other classes?

Brenda went to describe how, even when she was ill, she stayed late after class to write lesson plans, for the substitute the next day, because she did not want students to miss any of the material. This again illustrates the importance Brenda attaches to the notion of biological knowledge being composed of pieces of information outside the individual. The control over the communication process is self-evident; the substitute might divert from the planned curriculum content, therefore there is no flexibility for the substitute; i.e. she (the substitute) will bring Brenda's understandings of biological knowledge to the students. The interest in the communication process underscores the notion that biological knowledge is set and there is no subjective interpretation, separating the knower from her own personal knowledge.

Brenda states that she thinks more boys are probably interested in science than girls, however "it is getting closer". She perceived boys and girls to be equally interested in biology and overall, she found more girls taking her biology courses:

I: And do you perceive the male and female students as equally interested in Biology?

B: Yes. Especially the ones I have this year. The breakdown is very close in Biology 30 but overall in biology, there are more girls.

I: Do you think that more females go into biology than into the Physical Sciences?

B: Yes.

I: Alright. Can you think of a reason for that?

B: I think that they have been geared that way. Males are encouraged to be more math oriented and to take chemistry and physics, because of the careers that they are going to pursue afterwards. And well, females they become nurses, so they take Biology. But I think that's changing and females are pursuing all kinds of careers . . . especially like with the WISEST conference and from certain posters I've seen: "I want to be an engineer like my Mom". And things like that.

Brenda is familiar with the WISEST participation in high schools across the city and encourages her girls to participate. She states clearly that she thinks "things are changing" and that females have more career options to choose from. However, of the number of student instigated questions in her class, more came from the boys than from girls, and Brenda directed more questions to the boys than to the girls in her class (see Appendix C). When asked about this in an informal discussion, she responded that it was because girls were more mature and would "think before they spoke." She did not realize that she was directing more questions to boys and indicated she would make a mental note of that and encourage more girls.

4. What, according to the teacher's definition, constitutes biology as an area of study?

As an area of study, Brenda indicated that biology was a life science and that it was "more active than a physical science . . . with more application to things . . ." She stated that biology was a more relevant science to the understanding of human things and that she was drawn to it, personally, through its human applications. Brenda's personal aspect of 'knowing and understanding' about living things, was incorporated into the way she augmented her lecture material from conference and magazine references; and from the medical applications, and technological applications which she mentioned in class.

There is ambiguity in Brenda's understanding of the relationship of biology to society - to the individual, and to her understanding of how scientists perceive the relationship of biology to society:

I: Do you think that the sophistication of our technological equipment assists us?

B: Oh yes.

I: Do you think that science has limits?

B: Yes, because scientists are human . . . Scientists are just the experts to rely on for information and advice.

I: . . . Do you think that emotions or feelings should be part of decisions we make about which problems to pursue in Science?

B: Yes. Although sometimes I think that if they interfere too much they might block 'good' decisions. But because you are dealing with living things it has to come into play.

I: When you say 'block good decisions' - can you give me an example?

B: With things like genetic engineering . . . I don't think they can pursue things to the extent that they technically could . . . because they're afraid [pause].

I: Yes? [pause] Well, if you are worried about the moral views about this kind of knowledge - then do you think morals and ethics are important in making decisions about what kind of research to do?

B: Yes. I think so. But the scientists who are doing the research would probably say no because you are letting your feelings get in the way. Maybe you are preventing us from discovering something.

I: So you see a difference between the way you perceive the place of ethics in scientific research and the way an actual scientist might perceive it?

B: Yes. I associate scientists with complete objectivity, really.

Although Brenda felt that science was a human endeavour; that ethics should be involved in the decision-making process about which problems to pursue in science,

she felt her position was not held by mainstream science. In this sense, objective knowledge which was held by scientists, was legitimate knowledge. This explains why Brenda felt obligated to present her content as empirically bound.

Brenda incorporated several labs into her unit, however one of the labs was omitted because "in the past we found we couldn't get consistent results with the old equipment." Brenda's understanding of scientific experimentation was that it uncovered facts and when a sufficient number of experiments verified the factual information it became incorporated into biological knowledge. If facts were inconsistent, the research was flawed and it could not be presented to students as valid and reliable biological knowledge. When asked what the scientific method was, she stated further, in her interview, without hesitation:

B: Oh, it's identifying a problem, hypothesizing, analysing the data and verifying the hypothesis.

Brenda's understandings of this legitimate way of doing science guided her decision to discard the failed experiment. Indeed, throughout the course of the research study, there was no mention by Brenda of discarded theories, conflicting facts, or unreliable data. Biological knowledge was "given knowledge"; knowledge from experts; knowledge confirmed by validated scientific experimentation.

Her mechanistic understandings were confirmed by the researcher when Brenda was asked about the impact of the new STS curriculum:

B: Well, from what I've seen of the chemistry . . . like when I taught it . . . I taught the old one . . . Alchem . . . just from what I've heard from a few people around me teaching it now . . . uhmmm. . . they say in some units they go overboard on that part of it [referring to values in science and society] . . .

I: . . . Now disregarding how they feel about it, how do you feel about that - do you think that you can do too much in the area of science and society . . .

B: Yes, I think you need to include that definitely, as part of your course . . . your science course, but ya, you can get too much into that and not enough into scientific facts.

Brenda was in conflict about her personal understandings of biology - those personalizations which made it interesting in discussing moral and ethical issues - and her learned empirical approach which verifies factual information according to the scientific method and does not rely upon opinion. The latter was the general manner in which Brenda presented her biological knowledge.

5. What is the rationale for the teacher's knowledge?

The knowledge base for Brenda's understanding of biological knowledge comes from an empirical 'knowing'. There is order to the Universe; there are absolutes, and lesson materials are presented in a very orderly, sequential pattern which reflects the orderliness with which Brenda perceives scientists engage in their own research. In the formal interview, she states that science helps us to define absolutes:

I: What does being objective mean to you?

B: Well, it means rational . . . not letting your personal views interfere - basing your decisions and opinions on facts.

I: Do you think that most scientists are objective in the way they go about doing their work?

B: Yes.

I: . . . Do you think that science helps us to define absolutes?

B: Yes.

The interview goes on to discuss laws and theories and whether laws and theories are the same thing as 'truths'. Brenda felt that if laws were verified then that was the same thing as 'truth'. There could be conflicting facts and therefore theories could not be proven as 'truths'. Brenda felt we discover biological laws that already exist and change in science comes about from new innovations in technology which allow more accuracy in assessing those laws.

The idea of theory-independent facts, constituting the incorrigible foundation of knowledge identifies a positivist theme. There is a strict commitment to a fact/value dichotomy, with strong legitimation of empirical knowledge as 'scientific knowledge'. Brenda incorporates a realist notion of knowledge; that is the objects of scientific knowledge exist and act independently of the knowledge of them. Hence, the objects of scientific inquiry exist and act independently of scientists and their activity. There is a teleological understanding of the tendency of knowledge to progress towards an ever more complete understanding of nature through elaborated techniques such as controlled experimentation, the use of scientific quantitative techniques and verification, and advanced technology.

Like Lillian, there is a dualist notion of contextual understandings and empirical understandings in scientific knowledge: dualisms are consistently observed between subjectivity/objectivity; active/passive [biology the active science/biology the science being acted upon]; values/facts. Lillian could theorize these dualisms, but was ambiguous in the practical application of them. When authoritative claims were made regarding objective knowledge then students were led to believe that legitimate knowledge was objective, factual knowledge. Brenda had no trouble presenting these dualisms both theoretically and practically. Students were

consistently told that her opinion or value position was subjective - and that these values were not legitimated scientifically. In both cases, empirical scientific knowledge was presented to the student as legitimate knowledge.

CHAPTER 6

DISCUSSION, CONCLUSIONS AND IMPLICATIONS FOR SCIENCE TEACHING

Introduction

This chapter presents an interpretation of the 'texts' of the two women science teachers - Brenda and Lillian, within a feminist post-modern epistemological framework. This chapter stresses perceptual change: a change brought about in the researcher's way of "seeing"; a change brought about in the interpretive framework within which Brenda's and Lillian's way of teaching is analysed; a change in the educational and sexual ideology which insists upon observing and interpreting as a man.

Brenda's and Lillian's texts become both metaphor and theme, in that narrative patterns which reveal 'ways of seeing' which connect educational to sexual ideology, become tools for revealing relations of power. Women have been trained to view themselves through masculine eyes and to the same extent, Brenda's and Lillian's narrative patterns metaphorically reflect this vision. If we acknowledge that in post-modern feminism's understanding of women's relationships to 'knowing', to 'objects' of study, there are textual incongruities which signify repression, i.e. these incongruities being the gaps and silences, the absence of the female voice in texts, then we can examine power relations which serve to preserve male authority.

Pagano (1988, p. 338) as a post-modern feminist, in *Teaching Women* states,

> Was there ever a life more riddled with self-doubt than that of a woman teacher? What is it that she doubts? The dominant forms of knowledge, privileged ways of knowing and thinking and speaking.

The author argues that high status knowledge - that is, objective, inferential and principle-based knowledge - mirrors the objective, inferential and principle-based knowledge of paternity. She argues that men come to their knowledge through inferences about causes and their effects. This knowledge is legitimated through traditional patriarchal privileging; that is, like the father to the son, the scientist comes to know through his privileged entry into the same gendered paradigm. Women's knowledge threatens the father's order; it is a knowledge which must be refused admission to that order. To know ourselves as women, is to know our knowledge as illegitimate - outside the father's order. Hence, was there ever a life more riddled with self-doubt than that of the woman knower - the woman science teacher? (1988, p. 338)

Which interpretative frameworks do our teaching narratives represent? If indeed, in women's narratives, the suppressed speech, the haunting image in the mirror which the female 'Self' sees in female 'Other' is the given, then where is the female voice - her authenticity - her authority? Are our teaching narratives simply extensions of men's texts? As Pagano and post-modern feminism suggest, the continuing problem for women teachers is authority: "the business of authority and in what it consists, who can legitimately exercise it, whether it is possible for a female teacher to exercise or be in authority, continues to figure as a prominent theme in discussions of women teaching . . ." (1988, p. 321).

Pagano explains that when teaching in the classroom is considered to be an enactment of narrative - of 'text' - authority refers to the power to represent the teaching narrative, to signify and command compliance with one's acts of signification (p. 322). In this sense, authority eludes women; they do not represent the signifier of authority: "the author is the father" (p. 322). This understanding is explored in relation to the texts of the two female science teachers.

The analysis in this chapter assumes that the methods, assumptions and goals which have served to preserve male authority need to be critiqued in light of feminine ways of 'knowing', of constructing goals. The science educational stories that we tell and our readings of these stories are not universal but gendered; hence, our understandings of text, our science teaching, and the implications our teaching has for female students in the classroom must be critiqued in light of the traditional patriarchal framework of 'knowing'.

"I", The Researcher

In this critique, the object of knowledge is not the personal property of the science teacher alone, rather a dialogue evoking the critical reflection of both the researcher and the teacher ensues. In this context, the researcher's personal understandings are a connected part of the analysis presented.

As a science teacher, over the past eight years, I have been listening to both men and women talk about teaching and about themselves. There is a clear distinction in my understanding of the way that women represent themselves as teachers, and in the way they understand their relationship of self to 'Other'.

At some point, my understanding of this difference led to a perceptual change. Was it that I had simply stumbled upon feminist theory and that gender differences written into the literature simply wove a new plot into my conceptual fabric? Suddenly, my contextual fabric came into play. Against my background of thoughts, experiences, and interpretations came a distinctive voice. This was a voice that was not included in the mainstream curricular and instructional research of educational literature. The narrative patterns reflected in this voice did not fit mainstream understandings of curricular thought. Curiously, as a researcher, I found this voice expressed in the narratives of Brenda and Lillian.

The narrative patterns which I will describe however, are reflections of Brenda and Lillian only, and to some extent of myself the researcher. They are characterized by theme and by gender, although I suspect that some themes which arise are found in masculine narratives as well. These are themes however, which are not supported by patriarchal and hierarchical 'ways of knowing' and hence, are not supported within the larger mainstream of dominant paradigmatic curricular and instructional thought, which has been identified as empirical and positivistic in nature.

It is important to state that the themes to be described here represent perceptual changes in modes of interpretation and understanding, rather than generalizations about distinctions between the sexes. The understandings of 'text' and of science teaching, and the implications our teaching has for female students, needs to be critiqued in light of traditional frameworks of 'knowing'. Further, it is clear that there are many variables which contribute to the functional classroom paradigms of science teachers, both male and female. These variables: the

sociocultural environmental milieu; the psycho-developmental backgrounds of the teacher and the learner; the curricular concerns of the subject matter - these complex variables clearly muddy attempts to differentiate between distinctive gendered differences of teaching experience. My interests lie in the understandings and interpretations which we bring to womens' teaching narratives. What kinds of dialogue do they express and what do these dialogues have to say about the kinds of teaching stories which tell about our lives as women? Clearly, hermeneutical studies, ethnographic studies, critical studies suggest that our dialogues are significant. Gilligan (1982, p. 2) in, *In a Different Voice*, states that "the way people talk about their lives is of significance, that the language they use and the connections they make reveal the world that they see and in which they act".

A feminist analysis of the texts of Lillian and Brenda can lead us to 'see things differently'. We can then examine alternative epistemologies which emerge theoretically, to see what they might contribute to science teaching practice.

A Feminist Synthesis of the Texts of Lillian and Brenda

Consistent with post-modern feminism is the feminist critique which attempts to reveal underlying patriarchal orderings of knowledge in the narrative structure. As earlier stated in the research design in Chapter 4, a feminist interpretation of the guiding question's subject and pedagogical perspectives can lead to a synthesis. The specific questions, according to the research design, are outlined as follows:

1. What are the underlying intents and assumptions of the guiding question's subject and pedagogical perspectives? To what extent are these intents and assumptions part of the traditional patriarchal functional paradigm?

2. To what extent is the traditional patriarchal theoretical framework in science teaching internalized? To what extent is protest exhibited?

3. What teaching social relations are implied by cooptation of this patriarchal framework? What views of female students are implied?

4. What knowledge is selected and neglected? Who controls the dissemination of knowledge?

1. **What are the underlying intents and assumptions of the guiding question's subject and pedagogical perspectives? To what extent are these intents and assumptions part of the traditional patriarchal functional paradigm?**

Underlying positivist themes in both Lillian's and Brenda's texts are an extremely influential intellectual trend which forms the generally accepted view of science, as defined by the traditional paradigm. Science is presented as an objective force above and beyond society. It is seen as a monolithic power, claiming to be the arbiter of truth. At the personal level, the claim of 'objectivity' divorces scientific knowledge from any emotional or social commitment.

Feminist empiricism adheres to these existing norms of scientific truthfulness. It simply argues that sexism is a social bias correctable by providing opportunities for an enlarged perspective, with more women scientists who are more likely than men to notice an androcentric bias. Within this feminist epistemological framework of 'knowing', the woman teacher coopts the traditional paradigm and looks for opportunities to encourage more girls to participate in science.

Indeed, this is what appears to happen to Lillian and Brenda. Brenda's text reveals that she legitimizes her knowledge through a mechanistic and empirical epistemological framework. This assures her authority in the classroom, in that students do not challenge empirical knowledge claims. She does however recognize

that increasing the number of girls in scientific fields is an expression of a feminist interest and she is active in recruiting for WISEST.

Lillian experiences discomfort in coopting the traditional epistemological framework and her ambivalence in contextual understandings versus some of the more empirical claims is expressed to students, who in turn, dichotomize values and facts. Her understandings of feminism are also related to increasing the number of girls who pursue a scientific career, although she does not participate with WISEST.

The underlying assumptions of this framework still incorporate traditional patriarchal understandings in the concept that a key origin of androcentric bias can be found in the selection of problems for inquiry and in the definition of what is problematic in scientific phenomena. The belief that the social identity, and hence, the gender of the observer can be an important variable in the potential objectivity of research challenges the assumptions upon which feminist empiricism are based.

The feminist standpoint recognizes that feminist critiques which incorporate the uses and abuses of science and its technology, have revealed ways in which science is used in the service of sexist, racist, or classist social projects. The key construct in this analysis is one of control. Are the underlying assumptions of scientific research inquires operating upon elements of classist or sexist control factors?

In Chapter 2 it is argued that the structure, ethics and politics of science take on a distinct androcentrism. Keller (1985) suggests that the basic dualism which posits a subordinance/dominance relationship in women/men maintains patriarchal relations by means of its very coherent scientific model of discourse. Harding (1986) extends these ideas by arguing that social, political and economic constraints

explain why some scientific ideas gain social legitimacy and others do not. Although Brenda and Lillian do not converse about sophisticated sociopolitical or sociocultural causative factors, both teachers believe scientific knowledge to be gender neutral, in the sense that objectivity is classless, unbiased, non-sexist. In this sense, their empirical understandings actually legitimate the underlying control factors which emerged both in their subject material and in their teaching styles. Both Brenda and Lillian incorporate a 'cause-effect' understanding into their subject matter presentations to students, delegitimizing value statements, and presenting knowledge as linear, sequential, and predictable. Their teaching styles reflect an expert/non-expert approach.

As indicated in Chapter 2, Smith (1979) points out that the standpoint epistemologies are grounded in those shared characteristics of *women as a social group*. Women as a social group, are ignored by both Brenda and Lillian, as having an impact theoretically on scientific knowledge. In turn, scientific knowledge does not account for or legitimate women's social knowledge. The underlying assumption that science is gender neutral legitimates the fact/value dichotomy and maintains dualisms between the teacher's social knowledge and their empirical 'ways of knowing'.

In the feminist post-modern epistemological framework, underlying assumptions and intentions of the traditional patriarchal knowledge paradigm are completely revealed and deconstructed. Feminist post-modern interpretations explore women's relationships to knowledge, to 'objects' of study. These relationships are of mutuality rather than invasiveness or dominance, as seen in the traditional paradigm. Post-modern theory suggests that women are attuned to

objectification, hence their disempowerment leads to contextuality and inclusiveness as cognitive frameworks and modes of perceiving. Women's 'narratives' reveal that they come from a different framework, no less legitimate than that of the androcentric experience. Lillian's narrative reveals ambivalence and discomfort in the traditional paradigm. Her perspective incorporates motherhood, child-bearing, and a sense that values and ethics are part of the problems to be selected for discussion.

Feminist post-modernism not only reveals the limitations of the traditional empirical patriarchal paradigm, but recognizes that the traditional paradigm restricts estrocentric views of natural, scientific and social reality as contextual; therefore inclusive, ontological dimensions which occur within human reality and are hence a part of scientific 'knowing', are nullified by an empirical knowledge which precludes metaphysical and ontological dimensions.

A post-modern feminist narrative on science education, then challenges the traditional reading of Lillian's and Brenda's texts within a patriarchal paradigm. Their narratives are not simply extensions of men's texts. Indeed, Lillian's narrative clearly reveals her ambivalence in her relationships to empirical knowledge and to relations of power, and her own discomfort in cooptation of understandings that are 'not her own' ('not her own', in the sense that because these understandings are constructed within another paradigm they don't hold the same meaning for her).

Brenda's narrative is complex in that upon decoding, its structure reveals tacitly held assumptions about the legitimation of knowledge. The current 'legitimate' characterization of science: scientific = objective = masculine, affects Brenda's understanding of masculine and feminine; these understandings do not

legitimate subjective and value-laden claims. Perhaps this is the reason why Brenda chooses not to discuss her pregnancy during the science class on circulation. She sees no relevance of her feminine being to empirical knowledge which she presents to her students in a very orderly fashion. These are not Brenda's 'own' understandings - they are understandings which she has learned from a traditional empirical paradigm.

2. To what extent is the traditional patriarchal theoretical framework in science teaching internalized? To what extent is protest exhibited?

Both teachers support an epistemological perspective which legitimates empirical knowledge. The traditional patriarchal paradigm with all of its underlying intents and underlying assumptions, is understood by both teachers to be a legitimate rationale for science educational practice. Their dualist notions of subjectivity/ objectivity; active/passive [as in biology the active science/biology the science being acted upon]; values/facts, fit into the paradigmatic framework within which they have been encultured. That their discomfort in this framework is not more obviously expressed, perhaps shows the extent to which the enculteration has been successful.

There is some protest exhibited to the traditional paradigm by Lillian. Her certainty in theorizing these dualisms, yet ambiguity in their practical application, stems from her recognition that personal values and 'feelings' are an authentic, subjective experience. These cannot be translated into the restrictive epistemological limitations of an empirical knowledge. Hence, her discomfort. Because there is no other authoritative voice, by which she could be guided, Lillian could not find a fit for these value or position statements. However, she did feel

they were important. After all, they guided her personal life; they led her into her professional career choice; they guided her understandings of biological knowledge.

Brenda did not have any difficulty accepting a dualist philosophy theoretically, nor did she have any difficulty translating this philosophy into the classroom practically. She understood the legitimacy of her empirical knowledge claims and although she too was guided into her profession through her own personal subjective experiences, ontological dimensions were not seen as legitimate 'ways of knowing' when it came to classroom interpretation. During the entire time that the researcher was in Brenda's class, there was no mention of her pregnancy or any other subjective feature which would acknowledge an ontological perspective which would give her own subjectivity an authoritative stance.

In fact, Brenda's narrative revealed that she never answered a question which was off topic, over the course of the research study, because a student never asked a question off topic. This is not simply pedagogical style. Inherently, Brenda placed control over her students' input by placing limits upon what was appropriate to discuss and what was not.

When Brenda answered a question on topic, she answered it according to her understanding of the knowledge of the subject matter but frequently used an authoritative phrase such as "Yes, I read in *Science World* that . . .", which legitimated her knowledge as being other than her own. Further, when students were required to research a topic in the Unit, Brenda interpreted which questions were appropriate to research and which were not.

Brenda has coopted the traditional patriarchal scientific paradigm which restricted the nature of the meanings and experiences she could bring to the

classroom. Indeed, it restricted her own knowledge of herself in relation to 'Other', as she could only know herself through a knowledge which was not her own. Post-modern feminism suggests that women's knowledge is subject to interpretation through male discourse in a patriarchal paradigm, and so her own understandings of her self are always subject to interpretation by 'Other' - an extrinsic source. Again, authority becomes an issue in terms of ownership of one's own knowledge, for women.

Pagano (1988, p. 325) and other post-modern feminists assert that gender is one of the fundamental categories according to which we organize our experience of ourselves and others. However, the voices of both Lillian and Brenda reveal that sentimentality, value-laden issues, personal or emotional issues are considered minor, judged against the neutral universal standards imposed by the totalizing tendencies of patriarchal discourse. If instead, as Pagano suggests, women's narratives could be presented as vital alternative visions to those which are patriarchal in nature, then our assessment of them changes.

If, in fact Brenda could present her pregnant 'being' within context of the value-laden and personal ethical implications such a state imbibes, then this does not need to replace empirical epistemological considerations, which in and of themselves have validity, but rather offer alternate epistemological considerations, as authoritative.

In this research study, both of these science educator's scientific knowledge structures which govern their classroom teachings are indeed revealed as gender-related and deeply entrenched in masculine and Western epistemological constructs.

3. What teaching social relations are implied by cooptation of this patriarchal framework? What views of female students are implied?

Was there ever a life more riddled with self-doubt than that of a woman teacher? Pagano, as a post-modern feminist uses subject-object relations theory,[1] like Keller (1985) to argue that women are represented by male interpretations and do not represent themselves. If this is accepted then what implications does this have for women teachers? Where is her authenticity? her authority? Education is about teaching people. In order to represent the teaching narrative, one must have authority to signify, to command compliance with one's own acts of signification. If the signifier is presented as a male - then, as a woman, representing authority becomes problematic.

Lillian's management problems are consistent with subject-object relations theory, which states that the male economy is impatient for products, definitive statements, and conclusive constructs which objectify; which have the power to control; which reveal the phallocentric obsession which dominates. Lillian had frequent run-ins with interruptive male students' sexual innuendos. Lillian used humour to appease these verbal assaults, yet she was not always successful. In explaining this, we might assume personality factors, years of teaching experience, i.e. gender-neutral factors which might also apply to a male teacher's loss of classroom control. But if we examine the theoretic base of object-relation's theory for an explanation and if we establish that teaching is not gender-neutral, what does this imply? If, as Keller and Pagano suggest, women inherently do not have the authority to command compliance with their own teaching acts, then Lillian's

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[1] See discussion of post-modern object relations theory in Chapter 2.

attempts to trivialize male students' comments through humour, only reinforce her own understandings of lack of authority in the classroom. When Lillian used an external authoritative factor - the departmental exam - to remind students of the teacher-student traditional social relationship, male students complied. Her teacher authority was often insecure. Only when she drew upon the patriarchal model of social relations, a hierarchical one connoting expert/non-expert relationships, could she establish an authority. It was not her own authority however. Her contextual understandings; her feminine understandings and need to incorporate personal practical statements of authority were not accepted as authoritative. It was an alternative epistemological framework which didn't fit in a classroom where traditional epistemologies reigned authoritatively in students' understandings.

Indeed, Lillian's personal narrative revealed that she inherently thought that boys interests were more powerful, i.e. she identified with their fields of study, as 'they were not as trivial as girls'. Girls were seen by her to be temperamental. However, as a woman she struggled to present what she considered to be significant information, i.e. health-conscious issues in relation to her children and students; moral and ethical understandings about AIDS. These were not illegitimate subjects in and of themselves, but Lillian was ambivalent about their legitimacy, hence this perception was incorporated by her students and reinforced by their own encultured understandings. That so many students asked off topic questions to Lillian, might not be indicative of students' own rebellious sets of understandings of value-laden issues, but rather indicative of a testing of the female teacher's understandings of these issues and their relation to empirical claims.

Brenda's lack of management problems might have indicated how well she had incorporated the traditional paradigmatic model into her own classroom teaching experience. Her authoritative statements dichotomized the knower from the 'knowing' and external legitimations were recognized as authoritative: quantified scientific verification, controlled experimentation and technological elaboration of technique. The established classroom relationship was of the expert disseminating this knowledge and the non-expect passively receiving the 'knowing'.

According to post-feminist object-relations theory, the objects of male scientific knowledge exist and act independently of scientists and their activity; hence the knowledge that Brenda disseminated, existed outside herself and she could not 'own' it. Nor, as has been suggested, would she have the authority to own it as a woman. Although this does not appear to be problematic for Brenda, as her classroom runs very efficiently and she does not have any management disruption problems, her students' knowledge claims are not given a grounding for testing. Very few questions are instigated by students, as students have assumed a traditional role within a hierarchial model, and as the non-experts are comfortable in passively receiving their information from Brenda, who represents 'the expert'. As long as Brenda abides by this coopted patriarchal tradition, confrontational events do not become a part of the classroom environment.

The student-teacher relationship is a father-son relationship says Pagano (1988, p. 338), in that knowledge is legitimated through traditional patriarchal privileging. Like the father to the son, the scientist comes to know through his privileged entry into the same gendered paradigm. But this paradigm is bound by rules. The estrocentric epistemological framework incorporated into post-modern

feminism which envisages contextual and hence changeable, nurturing constructs, is not a part of the traditional functional paradigm exhibited in this science class. Nor would these constructs have authority, within the traditional paradigmatic context that has been described.

Implications for female students

> How can the female teacher wean the female student from dependence on her, from preoccupation with her [the female student's] own subjectivity, to a mastery of the objective rules of the discipline and to an independent place in the disciplinary order. She represents a disciplinary canon - an institutional text - from which she is excluded, within which she must treat herself as 'Other' to herself.[2]

The implications for female students become clear as one observes the ratio of male: female questioning patterns which arise within the classroom context. Neither teacher internalizes the significance of their own discongrous questioning habits, except to note that 'probably girls are more mature and just don't ask as many questions.' That girl students are as excluded from the dominant paradigm of knowledge as the women teachers who teach them, is a construct both the women teachers and female students know. They simply do not know it in an articulated form.

Lillian's narrative reveals her struggle to establish authority within an alternative epistemological framework; that is, within an estrocentric one. Post-modern feminist critiques begin dialectically with analyses of we/women's ambiguous relation to power as is reflected in the language and knowledge structures of our

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[2] Pagano, 1988, p. 330.

narratives. In science, this power is closely bound to the male voice: a central voice. An estrocentric view of a natural, inclusive scientific and social reality which includes ontological dimensions, is excluded from the traditional paradigmatic view.

If, as a woman teacher, we/women are excluded from our own knowledge of ourselves; if this knowledge is not legitimated - then what implications does this hold for the female student who struggles to identify her own sense of 'knowing' - to authenticate it. If the female student must ascribe to traditional patriarchal 'ways of knowing' in order to be authoritative, then not only does she exclude her own 'being' from a legitimate knowledge source, but an entire alternative epistemological paradigm, i.e. a feminine one, is excluded from authoritative societal ideological acceptance. This is the radical nature of the position of post-modern feminist theory.

4. What knowledge is selected and neglected? Who controls the dissemination of knowledge?

Throughout the discussions, the knowledge which is selected by both teachers, as authoritative knowledge, is that knowledge of the dominant paradigm which the researcher has identified as traditionally patriarchal and empirically epistemological (positivist) in nature. The disseminators of this knowledge are male, experts and control oriented. That the teachers are female does not preclude their temporary ownership of such knowledge as both female teachers have coopted the disseminator's position. However, their authority to own this knowledge has been questioned.

In order to examine which knowledge has been neglected, the researcher would like to return to the maternal texts in the women's lives. Both teachers reveal

texts which speak to personal subjective experience as guides to personal and professional change. Contextual understandings, although seen as problematic, are deeply rooted in each teacher's epistemological theoretic understandings although rarely expressed in the practical functional paradigm of the classroom.

The feminist critiques in science have produced an array of conceptual questions that have threatened the extent of androcentrism in science and made it possible to formulate new questions about feminism and science. Harding (1986, p. 20) suggests that women are engaging in a "politics of knowledge-seeking" and that although the variety of epistemological positions: feminist empiricism, feminist stand-point, feminist post-modern, reflect instability - they help us to transform various patriarchal theories rather than simply revise them. Perhaps a full appreciation of the tensions and conflicts between theories is needed in order to transform the very context of inquiry from being inadequate to accommodating various positions. Harding (1986, p. 158) suggests that, "what feminism should distrust is not objective or epistemology's policy of thought per se, but the particular distorted and ineffectual form of objectivity and epistemology," entrenched in positivist and patriarchal understandings. In fact, what would be helpful to Lillian's and Brenda's scientific understandings might be the recognition that it is not the objective and empirical knowledge claims that are problematic, but the particular distortion of authority given to objectivity that needs to be re-examined. What other meanings can be authoritative?

Perhaps listening to the voices of women, to their narratives, and encouraging women to think in new ways about what constitutes knowledge, is a first step. The goal of this feminist 'knowledge-seeking' is to achieve theories which accurately

represent women's activities and understandings. In this sense then, these theories must foster pluralistic understandings - inclusive and multicultural understandings. Eclecticism could be received as a significant positive construct. Tensions and ambivalences within and between theories, whether feminist or other are not bad. Harding (1989, p. 244) also suggests that it would be premature and delusionary for feminism to arrive at a "feminist scientific unified master theory", as this inherently incorporates patriarchal notions of exclusivity and finality.

Implications for Science Teaching

> . . . a textual system in which gender serves as a fundamental organizing principle and women's relationship to the production of . . . knowledge is understood as different from that of men, brings us to a moment in which we must rethink what it means for women to practice . . . teaching and what it means for all of us who teach women.[3]

A feminist reading of text has implications for the knowledge claims that we might perpetrate as science educators. Coherent knowledge claims in an obviously incoherent world are oppressive and problematic, depending upon the degree of hegemony they manage to achieve. Feminist readings reveal incoherencies in knowledge claims that have traditionally been defined as objective, pure and unequivocal.

There are many levels to feminist inquiry which can question, re-define or re-theorize established canons of curriculum thought. There are pluralistic understandings, experiential in nature, by which we/women come to 'know'. Native

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[3] Pagano, 1988, p. 339.

women teachers' stories are different from white urban teachers' stories and these in turn differ from immigrant women's understandings of their own perceived reality, whether as teachers or as students. Yet, these stories are all womens' stories and this commonality ties us powerfully together. It allows us to question and/or redefine patriarchal understandings.

If we are all ethnocentric by experience, then we get at the phenomenology of other cultures through an anthropological cognitive framework, but we are a very long way off from being ecumenical. Even feminist endeavours have been coopted by institutionalized bourgeoisification. As Henry Giroux (1983, p. 52) posits:

> the value of a liberal critique of the hidden curriculum is considerably diminished by its insistence that the source as well as the ultimate solution to the problem of gender discrimination resides in merely uncovering and eliminating those sexist typifications that inform various social practices and aspects of school life. Excluded from this perspective, is the insight that gender discrimination may have a material power base outside the schools, and that the resolution of such discrimination may be more than an ideological problem.

If we can appreciate how female students of science come to accept certain meanings, then we have a basis for helping them to learn different meanings. If we aim to transform the consciousness of our female and male students so that they can recognize the divisions patriarchal ideology has created, then where ideology operates, we can address ourselves to new questions of learning.

What new questions of learning can we/women address ourselves to? If we return to the beginning of this chapter and acknowledge that:

1. the way that we/women talk about our lives has significance
2. the language we/women use is important

3. the connections we/women make, reveal the world that we see and in which we act

then, many possibilities open up for curricular and instructional revision. First of all, using gender as a category of analysis in the classroom could reconstruct meaning and could question underlying assumptions. For example, there are traditional medically-accepted interpretations for 'disorders' such as PMS. In a unit on reproduction, perhaps introducing bio-social and psycho-social theories of hormonal regulation might trigger different understandings in girls than in boys. In another example, it might be useful to recognize the category of gender in discussing careers. How does motherhood fit into becoming a doctor? Does being a professional microbiologist exclude motherhood?

And what of language? Being considerate of language insists that a generic use of masculine terminology, which implies that the male is the norm in society, must be eliminated. The usage of masculine generic terminology makes women feel excluded from discussions in the same way that androcentric assumptions in a field and empirical methodologies used, can alienate women from entering scientific or technological fields. It might be useful to present interdisciplinary perspectives, in that discussions of a philosophical, ontological and ethical nature can be legitimated in their proper epistemological and ontological frameworks, and be seen to have a bearing on empirical knowledge claims in science.

In order to foster pluralistic understandings it would seem important to pay meaningful attention to intersections of gender, race, class and cultural differences. For example, examining sociobiological genetic and environmental cultural determinants in human development, might lead to interesting class discussions.

Knowledge claims could be tested within a population of both male and female, North American and ethnic perspectives.

If knowledge claims in science appear immutable, and hence, unpalatable to the contextual frameworks of women and girls, then perhaps content might be presented as historically, culturally and socially bound. An examination of Darwinian views in the theory of evolution, within their historically-bound context in relation to current genetic-evolutionary theories can reveal not only the impact of a culture and society on the development of a theory, but reveal that theories are mutable.

Rather than 'adding on' women representatives, incorporating analyses of gender, race and class into the available knowledge claims, makes the students' experiences part of the implicit learning process of the course. Also, students' discarded theories and failed experiments are an integral part of the learning process and help students understand how new paradigms of knowledge come into place.

It is important to recognize girls and women as a group, rather than individuals meeting male norms. Focusing on difference, conflict and change would seem important in testing the universality of knowledge claims in the classroom. Conflict as an agent for change is a requisite in encouraging students to pay serious attention to meaningful intellectual debate. It is also important in fostering mutual respect for conflicting understandings.

Finally, the time is judicious for reflecting upon and re-examining political, environmental and ecological issues in the classroom. An alternative epistemological model might present an interactive model of personal and curricular change. This might include a collaborative curriculum, based upon global imagery of self and

society, including ontological and ethical dimensions. This includes a global reflection upon environmental, feminist, political and ecological moves which affect science and it's knowledge.

Summary

There is a special contribution that a feminist inquiry into scientific 'ways of knowing' can make. Feminist critique can sit itself quite firmly at the juncture between science curriculum theory and practice: the possibility of a real dialectics within which a total, specific, 'feeling' and thinking subject, present in her interaction with 'objective' materials, mediates the possibility for social action and emancipatory transformation. This transformation of educational practice in science, requires not only a redefinition of women's place in science, but a redefinition of science. This infers a critical examination of our current science educational practice. This also includes a critical reflection upon science and technology within a global ecological context, with a dialectics in our educational practice which reflects this context. Convergently, these emancipatory moves - feminist, ecological, educational, rely on each other.

To do this involves a 'sublimation', as in Gallop's (1982, p. 112) *The Daughter's Seduction: Feminism and Psychoanalysis*, where, "one gives up an infantile, unmeditated relation to *jouissance* (trans. "possession"), and operates in the register of metaphor and mediation," as this thesis has attempted to do.

To teach the reading of science stories is indeed a major task of feminist inquiry. Metaphorically, 'ways of seeing', will thus be altered. Understanding that indeed principles of duality, hierarchy and competition have framed the parameters

of the kinds of patriarchal science educational models we confront, can lead us to alternative understandings, based upon inclusive gendered, political and ecological complexities.

A feminist model of science education which incorporates this axiological complexity within context, is a model of conscientization. This is an enormous challenge. In the words of Henry Giroux (1983, p. 242) what this suggests, "is that radical pedagogy needs to be informed by a passionate faith in the necessity of struggling to create a better world."

Suggestions for Further Research

As an initial step in the recognition of a gender-related analysis of the epistemological frameworks of women science teachers, some possible research questions emerge from this thesis. As stated at the beginning of the chapter, it is clear that other variables muddy attempts to single out specific knowledge claims and so any attempt to grapple with Schwab's four commonplaces in assessing the functional paradigms of women science teachers would be useful. A consideration of psycho-social and cognitive influences in women, as well as learning developmental styles might seem as significant pursuits of interest in establishing gender-related claims.

There are a number of interpretive theoretical frameworks from which to study such topics: neo-Freudian or post-psychoanalytic positions incorporating feminism, such as object-relations theory, hold promise for alternative understandings. Feminist standpoint theories offer political and social

understandings of gender and might be useful in opening up alternative 'ways of seeing', about the interactions of women science teachers and students in the culture.

Studies which examine transformed curriculum revisions and their effects on knowledge construction in girls would be immensely helpful. With the revisions in the new STS curriculum in the province of Alberta, it would be valuable to study which knowledge claims become authoritative for male and female students. Ultimately the profound effect that the teacher has on the student, becomes a focus for the significance of the research.

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APPENDICES

APPENDIX A-1

OBSERVATION SHEET

APPENDIX A-1

OBSERVATION SHEET

TOTAL NUMBER OF MINUTES NOTE-TAKING -

TOTAL NUMBER OF MINUTES DISCUSSION (ON TOPIC) -

TOTAL NUMBER OF MINUTES DISCUSSION (OFF TOPIC) -

TOTAL NUMBER OF MINUTES LECTURING -

TOTAL NUMBER OF MINUTES MANAGEMENT DISRUPTION -

NUMBER OF DIRECTED QUESTIONS (GENERAL) -
ANSWERED -

NUMBER OF DIRECTED QUESTIONS (SPECIFIC) -
ANSWERED -

NUMBER OF STUDENT INSTIGATED QUESTIONS (ON TOPIC) -
ANSWERED -

NUMBER OF STUDENT INSTIGATED QUESTIONS (OFF TOPIC) -
ANSWERED -

APPENDIX A-2

EXAMPLE OF CLASSROOM TRANSCRIPT

EXAMPLE OF CLASSROOM TRANSCRIPT

Lillian: Day 6 of Research Study

12:00 - 1:24 p.m.

Transcription includes classroom discourse recorded on a tape from 12:03 until 12:50 at which time the recorder was turned off. Student teacher takes over the class at this point, and introduces the new unit. (This student teacher time: 12:50 - 1:24 p.m. is not recorded). Written observations of the class events have also been included and indicated in brackets [ ].

12:00 - 12:05 p.m.

[Class starts at 12:03 p.m.]

L: Put your books away. [Lillian moves around class to distribute quiz to students]. This quiz is important.

[♂ (s) enters classroom late and speaks to Lillian].

(s): I like your hair today! [(s) takes his seat].

L: What's your problem today (s)?

(s): I lack a writing utensil.

L: You lack more than that (s)! [laughter].

♀ (s): Here's a pen. [Gives pen to (s)].

12:05 - 12:10 p.m.

(s) Hey, anyone want to see my art? [(s) displays a drawing from an art class, for the class to observe, but nobody comments. (s) writes the quiz and is the first to walk to the front of the class and return the paper to Lillian]. How did I do?

12-10 - 12:15 p.m.

L: As usual, you could do better. [(s) does well academically in Biology 30, so the inferences behind this remark are meant to control his current interruptive behavior. (s) returns to seat and turns around talking to ♂ student behind him . . . this conversation is not heard by either L or the researcher].

L: (s) don't talk to ♂. [Other students return quizzes to L at the front of the room and there is some chattering in the classroom].

12:15 - 12:20 p.m.

[There continues to be a lot of talking in the class, although not everyone is yet finished their quiz. Three boys in disruptive corner are passing around candies. One yells over to another student across the room, engaging the student in conversation. Another ♂ student talks to a girl in front of him. L walks over and takes quiz off his desk].

L: I assume you've finished? [L goes to three boys in disruptive corner]. Why are you eating junk food? You're not looking after your body! [L moves to the front and waits a minute]. Are you all finished, yet? [Three ♂ students indicate they are not].

12:20 - 12:25 p.m.

L: Oh, I've changed something very important - your exam! [Two ♂ students ask why, when?]. Because the kidneys didn't come in! The kidneys for the lab didn't come in. The cow eyes are also coming - so we'll do them both together - they won't be in for a few weeks. Because of the lab day, I'm moving your exam up a day. Everything we've covered so far will be on the exam - it's worth 8%. This quiz is worth 1% - which is quite a lot of this unit.

♂ S: What's a good liver worth?

L: [Ignores remark]. The new unit which the student teacher will present to you on sensory organs, in the nervous system, is next.

♂ S: What new unit?

♂ S: What are we going to do?

♂ S: A student teacher?! [There is some discussion on this by students amongst themselves - L watches them but doesn't say anything].

12:25 - 12:30 p.m.

L: When the required lab materials come in we will set dates for the labs and when the new student teacher starts the unit, which by the way is today [students start talking briefly to each other], we will let you know exam dates and exam weighting. O.K., now, last unit's lab on Cellular Respiration - here they are. [L distributes labs to students who come up to receive their labs - there is a great deal of talking between students and between L and students concerning each individual mark so during transcription of this, it is difficult

to assess individual student responses. There is a large group of students at the front of the classroom. As students return to their desks, individual responses become clearer].

12:30 - 12:35 p.m.

(s): Oh Jesus! [There is concern and talking among all the students as the marks appear low. (s) moves up to the front again to L. They appear to negotiate his lab mark, which does not appear to change and (s) returns to his desk].

L: ♂ S - I don't seem to have a lab for you?! Why?

♂ S: I forgot to do it.

L: You cannot not afford to hand in your labs, ♂ S! [Turning to another male student] ♂ S, do you enjoy collecting eggs? [Turning to a female student] ♀ S, you let me down, you didn't hand your lab in!

♀ S: Oh, I'm sorry, I really . . .

L: I know ♀ S, I'm just disappointed.

♂ S: When is our exam again?

♂ S: What's today's quiz out of?

12:35 - 12:40 p.m.

L: I will have the quizzes back for you tomorrow. [(s} moves out of his seat and look at the student teacher who is sitting at the back right corner of the room]. Sit down (s). Our student teacher won't be teaching until the second class after the break. O.K., now, let's review a little. You need to understand the difference between plasma filtrate and urine in order to understand Excretion. We'll go over this again tomorrow before your exam.

♀ S: Could you discuss tubular reabsorption?

L: Yes, let's turn to p. 384 [in required text, students turn to page] to see how the nephron works. Ions are pumped out of the tubule . . .

♀ S: Well, it doesn't say if Na^+ ions are moved out of the bloodstream?

L: Well, it doesn't really explain it, but let's look back at p. 382-3. You must know the difference between active transport and diffusion - you have a sodium pump working here . . . [Three boys in disruptive corner are talking]. Yes boys, this is a bit confusing - you have a sodium pump working here and you need energy to move the sodium ions out . . .

12:40 - 12:45 p.m.

. . . there will definitely be a question on this on the departmental exam - so you need to know the sodium pump. You need to understand that the nephron maintains a balance of ions and solutes - what would happen if there was an IMBALANCE?

♀ S: It would swell . . .

L: What is this called?

♂ S: Gout.

L: No, it's called edema . . . [spells it on blackboard]. Edema. What are you doing S? [Turns to ♀ S].

♀ S: Uh, well . . .

L: S, you're just like a little old Baba, handing out raspberry candies!

(s): A Ukrainian Baba! [Students laugh].

Bell rings at 12:42 p.m. Break until 12:45 p.m.

12:45 - 12:50 p.m.

L: O.K., just a comment on your lab. Who has a suggestion on how we could measure CO_2 in inhaled air? How about you, ♂ S?

♂ S: Measuring lung capacity.

L: Lung capacity? How does this affect inhaled air? [No response]. Well, do you think physical fitness has anything to do with CO_2 in inhaled air?

(s): I think . . .

L: I didn't ask you (s), but ♂ S - what do you think?

♂ S: Amount of CO_2 depends on amount of O_2 in the lungs?

L: Well, this is a different question but which is it? Does CO_2 depend on O_2 or O_2 depend on the amount of CO_2 in lungs?

♂ S: Well . . .

L: [Waits but no response]. Well, CO_2 acts as a stimulant to respiration so?

♂ S: O.K., so O_2 depends on CO_2 in lungs?

L: Good. This is definitely on the departmental exam. (s) are you listening? [(s) is talking to two ♂ S around him]. Now, we are just going to introduce the Nervous System briefly to you today. I'm going to let Miss _____ give you some notes on this.

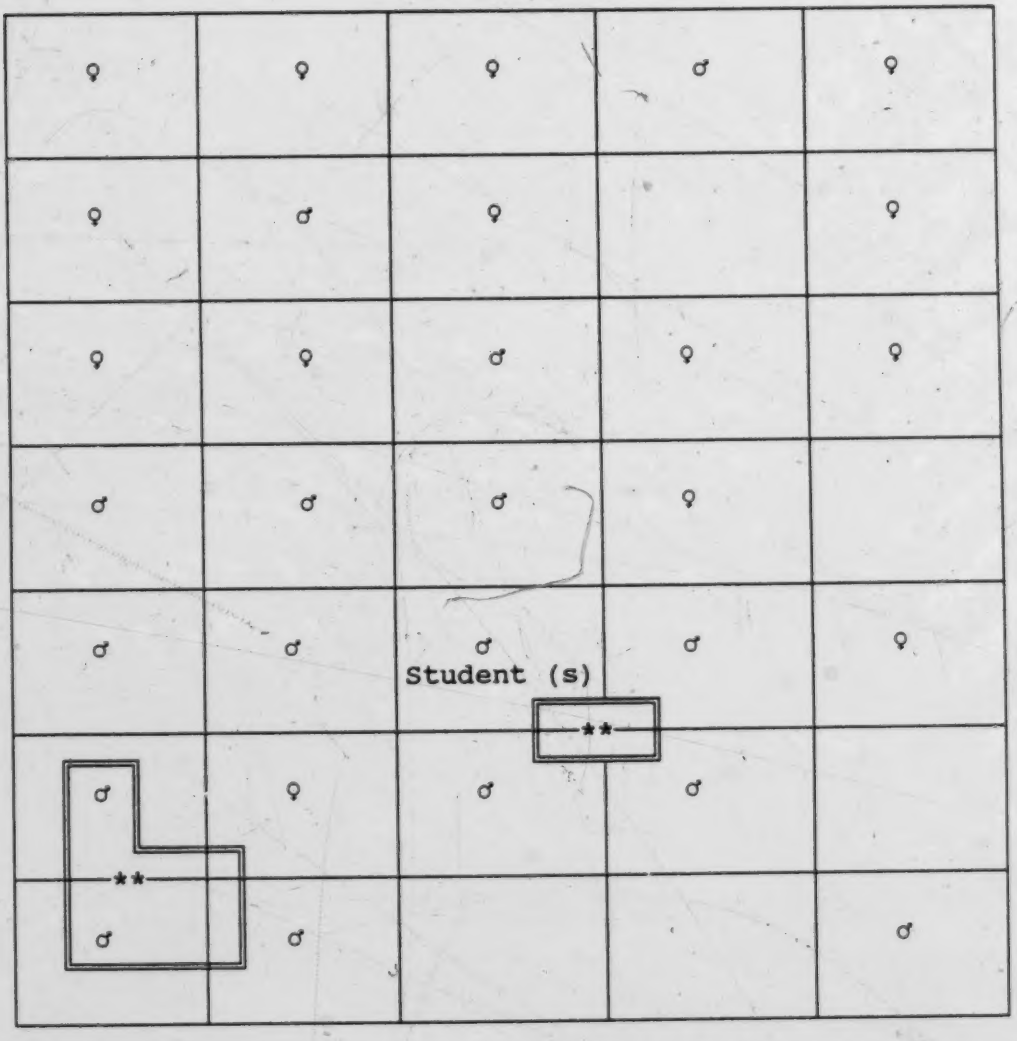
Recorder turned off.

APPENDIX B

CLASS SEATING ARRANGEMENTS

Teacher - Lillian

Classroom Arrangement of Students



30 Students: 14♀/16♂
** Management Problem
(s) Identified student in narrative

Teacher - Brenda

Classroom Arrangement of Students

	♂		♀	
♂	♂	♀	♀	♀
♂	♂	♀	♀	♀
♀	♂	♀	♀	♀
♀	♂	♀	♀	♀
♀	♂	♀	♂	♂
♂	♂	♂		♀

31 Students: 18♀/13♂

APPENDIX C

OBSERVATIONS ON TEACHERS

OBSERVATIONS ON TEACHERS

General Information

- 11 teachers in Science Department; 1 lab-tech. position
- large urban high school of a wide cross-section of low, middle and high socio-economic groups with large ethnic populations of Ukrainian, East Indian and Sikh.
- 2 female teachers: Lillian and Brenda (both teach Biology 30).

OBSERVATIONS ON TEACHER - LILLIAN

8 DAYS: 84 MINUTE PERIODS

Day 1-4 80 minutes recorded (4-5 minute break) each day

Day 5 Extension of social activity. Pancake breakfast - 29 minutes. Other 55 minute period not tabulated for questions, because of alternate presentation (social activities)

Day 6-7 80 minutes recorded each day; last 20 minutes of student teaching not recorded. (Note - not tabulated for questions - student teacher introduces new unit)

Day 8 80 minute EXAM

- Total Tabulated Unit time: 508 minutes of class time; not including 80 minutes of exam time, and 84 minutes of social activity

- Time includes a lab on Aerobic Respiration from the previous unit; (Note - one lab, for the current unit, on Kidney function and structure, was rescheduled for a future date because the kidneys had not arrived on time.)

Total Time Allotted for Various Activities

- Combination of note-taking/lecturing (both are incorporated into Lillian's style): 47 minutes
- Lecture-discussion (on topic): 123 minutes
- Discussion (off topic): 139 minutes
- Lab: 25 minutes
- Quiz: 11 minutes
- Management Disruption: 100 minutes

Total: 445 minutes; 63 minutes accounted for in extended breaks and starting and ending time of class (approximately 10.5 minutes/tabulated unit day)

Question Analysis

- Total number of teacher-directed questions (general) - 133
  Answered - 47

- Total number of teacher-directed questions (specific) - 44
  To males - 35
  To females - 9

- Total number of student-instigated questions (on topic) - 60
  From males - 46
  From females - 14
  Answered - 41

- Total number of student-instigated questions (off topic) - 83
  From males - 73
  From females - 10
  Answered - 50

OBSERVATIONS ON TEACHER - BRENDA

10 DAYS: 40 MINUTE PERIODS

Day 1-4 40 minutes recorded each day (no break)

Day 5 Social Activity: Pancake Breakfast: No class tabulation

Day 6-9 40 minutes recorded each day

Day 10 40 minute EXAM

- Total Tabulated Unit time: 320 minutes of class time; not including 40 minutes of exam time and 40 minutes - social activity

Total Time Allotted for Various Activities

- Lecture with overhead: 106 minutes
- Student note-taking: 144 minutes
- Discussion (on topic): 16 minutes
- Discussion (off topic): 0 minutes
- Quiz: 15 minutes
- Management Disruption: 3 minutes (also note: 36* minutes accounted for in starting and ending time of class)

Total: 284 minutes; 36* minutes accounted for in starting and ending time of class (approximately 4.5 minutes/tabulated unit day)

Question Analysis

- Total number of teacher-directed questions (general) - 27
  Answered - 7

- Total number of teacher-directed questions (specific) - 22
  To males - 17
  To females - 5

- Total number of student-instigated questions (on topic) - 15
  From males - 11
  From females - 4
  Answered - 15

- Total number of student-instigated questions (off topic) - 0

APPENDIX D

SAMPLING OF INTERVIEW QUESTIONS

SAMPLING OF INTERVIEW QUESTIONS

1. **Clarify background of teacher:**

   - gender
   - years teaching experience
   - degree; specialized interest; undergraduate/graduate coursework (e.g. Philosophy of Science course? History of Science course?); other specialized levels of training and/or interest
   - aspirations for career; administrative work and/or interest in pursuing such?
   - are there any social/personal interests related to their science teaching profession?
   - any perceived experience in developing individual's professional interest related to gender? (e.g. any high school, college event in relation to science experiences, which stands out as being specifically male/female related)

2. **Conception of Biology as a discipline:**

   - 'natural' vs 'physical' science? What are the differences?
   - what constitutes 'Biology'?
   - what perceived relationship to technology exists?
   - what perceived relationship to society exists?
   - is there a perceived differentiation between theory and practice?
   - what does a 'Biologist', as a 'Scientist', do?
   - are 'Biologists' mostly male or female?
   - are male and female students perceived as equally interested in 'Biology'?

3. **Philosophy of Science as it relates to Biological Knowledge?**

   - what is 'Science'?
   - what is a 'Scientist'?
   - how do 'Scientists' know things?
   - how do 'Scientists' do things?
   - what is the perceived 'scientific method'? what is it's significance? or/is it significant?
   - what is 'objectivity'?
   - is 'science' 'objective'?
   - what defines 'truth'?
   - do 'absolutes' exist?
   - does 'Science' help to and/or define absolutes, if they exist?
   - can 'Science' verify truth?

- what and who causes change in 'Science'?
- does 'Science' have any limits?
- how does 'Science' relate to technology?
- does 'Science' relate to society?
- can/should 'Scientists' make rules for society?
- are 'Scientists' mostly male or female?
- are male and female students perceived as equally interested in 'Science'?

4. **Attitudes towards Science and its relationship to Biological knowledge**

- what is appealing about 'Science' to you?
- what is appealing about 'Biology' to you?
- do 'Scientists' 'feel' emotionally, in their work? should they?
- is 'Biology' a more emotional science than 'Physics' or 'Chemistry'?
- should emotions play a part in making decisions about kinds of scientific research, to pursue?
- should emotions play a part in making societal decisions about 'Science'?
- what attitudes would you like most to impart to your students about 'Science'?
- what attitudes would you like most to impart to your students about 'Biology'?

5. **Emphasis of Curriculum on Teaching (subject matter and pedagogy):**

- are there any differences in the way you teach Biology now, compared to when you first started?
- what different methods do you use, now?
- what does 'science teaching' mean to you?
- does the current 'Biology' curriculum meet these needs in teaching science?
- do you leave parts of the 'curriculum' out?
- how do you select what you 'add' to the curriculum? (what criteria)
- how do you perceive your style of teaching affected by the departmental exam?
- what constitutes the total grade of your student?
- does the current science division (chair) affect how you teach or evaluate science (biology)? is your chair male or female?
- do you perceive more girls or boys asking questions about biology, in your classroom?
- do you find students more or less interested in 'science' today, as when you first started teaching? (or the same)
- do you think your students are interested in 'Biology'?
- how important is a biology 'project', in your course?

- did you give 'tutorials', in this course?
- did you have any field trips, in this course?
- do you think it is O.K. to get off topic and discuss societal issues, if they are raised in class?
- do you think the new STS curriculum will be a positive or negative change for your students?

APPENDIX E

FINAL INTERVIEWS OF TEACHERS

FINAL INTERVIEW: TEACHER - LILLIAN

I: Researcher
L: Lillian

I: Alright, first of all, I just want to ask you some questions about your background. I'd like to know how many years teaching experience you've had?

L: I've taught part-time, all my teaching career . . . total accumulative full-time here, works out to about seven and a half years . . . but I have been in the system - Edmonton Public School Board, since 1977, so I'm in my eleventh year with the School Board, but I only have seven and a half years of full-time teaching, because I've done part-time throughout.

I: And what was your undergraduate work in?

L: A B.Ed.

I: And what was your major?

L: My major was General Science. And my minor is Ukrainian.

I: With a Ukrainian minor, it's possible you had other Arts or Humanities courses?

L: Yes.

I: Did you do any work in the History or Philosophy of Science?

L: No.

I: Do you have any other specialized areas of training?

L: I have a First Aid - St. John's Ambulance course. I've trained recently to do that tolerance and understanding review of books, through Alberta Ed., where you take texts and you go through them to see whether they are any questions or anything that would be intolerant for various cultures. It's a little course - a two day course - and then you get materials to do on your own. That's about the only other type of work that's a little different.

I: However, is that related to your interest in Ukrainian culture?

L: That one I started was Ukrainian. Right. They needed people to review Ukrainian texts. I was asked to come and take this course so we could get more people working on all the materials available - because there is a

shortage of resources in Ukrainian and they needed more people to review some of the materials coming out of the Soviet Union . . . so we can see if there is racial undertones or things not acceptable to our educational philosophy, here, in St. Albert.

I: Yes, that's very interesting. So that's sort of become an interest of yours . . .

L: Yes, I haven't done it too much though. I haven't had too much time for it - I did it last spring and the summer before.

I: Do you have any other interests related to Science? Anything in your personal life or in your hobbies . . . related to Science?

L: Yes, my husband is in the medical profession. So I'm interested in human biology, in general. He specialized in that area - he has a lot of knowledge about the human body. He has to deal with situations that, actually are more extensive than people realize. You can have a number of situations occurring in a medical office and you have to be very informed of everything . . . CPR courses . . . he has to have a medical every year and keep his health up to par. He's very health conscious, so I'm more sold that way than I probably would have been, had I not known him. And I have a personal interest in human health, because I basically have been fairly lucky healthwise - but I now reflect upon the fact that my parents didn't have the good health they could have had in their latter years. And I think back and try and think of factors that may have contributed to that. I'm interested in living a long time - as everybody else is.

I: So you find that, in a sense, Science does affect your personal life.

L: Yes, a lot of things I do and talk about in class, are things that I personally believe in and have read a lot about. I try to keep up on all of the new things that are coming out and I do quite a bit of reading. Magazines and newspapers . . .

I: What kinds of magazines?

L: Well, I always make sure I read the medical section in *Macleans* and *Newsweek, Alberta Report.* All of these have at least one section on health. We get *Prevention* at home , and my husband has subscriptions to all the medical magazines, so we get those at home too - one is called *Oral Health*. And there's always information relating to general health. I do try to keep up on most of them.

I: Alright. In your undergraduate training, when you were majoring in general science, what attracted you to the Science programme - why did you major in Science?

L: Actually I started out in Physical Science - I can explain that route I went. I was not able to take Biology and Physics at the same time, in my highschool. So I had to make a choice - because they were offering it back to back. Some students took Physics and some took Biology. Most of the girls took Biology. Two girls took Physics - myself and Irene - 10, 20 and 30 - and all the rest were males. My friend Irene is a nurse.

I: That's interesting . . .

L: Yes and I ended up getting into Biology eventually, but I did start out in Physical Science at the University, because I was interested in that.

I: Then was one of the reasons that you switched over to Biology, because you found barriers in pursuing the Physical Sciences or did your interests change and why?

L: My interests changed. I was not interested in Physics when I go to the University after, because in my first course - Physics 200 - I lost interest. But I didn't lose interest in Science in general. I was enjoying my Chemistry. I thought there's got to be another way to get around this . . . and they had the General Science programme. It was of no loss to me to switch into the General Science. It would still give me an opportunity to branch out a little bit more. That's why I went that route. I started taking some Biology and I took a Biology 100 course, in my second year and then started going into all the Biologies. I ended up taking Genetics and Physiology. I really got interested in it - when I started taking some of the more specialized courses.

I: Alright. Can you pin-point any reasons, though, why you might have preferred Biology to Physics?

L: I had difficulty with Profs. - I found the classes more interesting in Biology because I could understand the Profs. better. I had difficulty in Physics - there was a language barrier. I think that contributed to my turn-off in Physics. I don't know. I guess - well, you know, I had two children while I was in University - and you know anything that I took in Biology related to my kids a bit. Whereas Physics, was not related to my family life in general. So that was a factor. I was taking a Genetics course when I was pregnant with my second one. It was during summer and I was seven months pregnant and the Prof. gave me - I don't know - he made me feel a part of the class. He felt that I was the one who would really want to know about all that genetic information - because it really applied to me . . .

I: He was aware you had other children?

L: Yes, and he gave me a personal feeling for that course and made me feel really as a part of that class. He thought it was quite interesting how I changed over the six weeks. I came in the class and I was sort of - not too

big - and at the end of the six weeks I had grown quite a bit. I remember him commenting to me at the end of class - "You've really grown quite a bit in the last couple of weeks" . . . I was getting close to the due-date.

I: So he actually brought your personal situation into the classroom situation . . . into genetic factors . . .

L: Yes, he did. Like crossing-over or whatever. He'd say, "Oh ya, isn't that right, Lillian, wouldn't that apply to you?" I really enjoyed this man - he was just excellent - a really good Genetics Prof. I guess Profs. make a difference. I enjoyed more of my Biology courses than my Geology and Physics.

I: And in part, then, are you saying that interest could be related to your domestic situation - having children.

L: Yes . . .

I: And you found it directly applicable . . .

L: Yes, it sort of tied in with everything that I was having happen in my life at the time.

I: Are you enjoying your teaching, now?

L: Hmmmm.

I: And would you like to continue teaching Biology?

L: Yes, right now I'm at a point where I'm really enjoying what I'm doing and I can see doing it for a period of time, yet. Maybe I won't feel this way five years down the road . . . I might want to teach something different. But right now I feel really enthused about it.

I: And are you teaching anything else, right now, besides your Biology?

L: Science 11.

I: And are you interested at all in pursuing administrative work or further degrees?

L: Further degrees. I'd like to go back and get my BSc. This would require me taking six more courses and I know exactly which six I want to take, including a BioChem. I want to go back and take a few more courses in Science.

I: Is part of the reason for doing that to augment your teaching?

L: Yes. I feel that there are some areas that I've taught, that I'd like to know tons more information about. And I'd like to go into these areas further at the University, than what I've done myself. I've sort of scratched the surface of a lot of things. There are some key areas right now that I'm really keenly interested in.

I: And what is that?

L: Biochemistry. I'd really like to go into that field. Take another course. Get into it a little bit more.

I: You mentioned that you had some Physical Science courses at the beginning, of your undergraduate work. What do you perceive the differences to be between the Physical Sciences - Physics and Chemistry, and the Natural Sciences - Biology?

L: Well, I just feel that Biology, in itself, is more personal. It applies to - well so does Physics and Chemistry too - but there seems to be more down to earth information in Biology, than in Physics.

I: Alright.

L: It seems like it's more readily available; it's more every day things that we do . . . that is applicable in that area.

I: O.K., Lillian. This next question might sound the same. What constitutes 'Biology' to you?

L: Biology is anything and everything about living things. That's sort of general.

I: So you perceive Biology as being concerned with living organisms rather than inanimate systems or abiotic factors?

L: Right.

I: You mentioned that Biology was personal. How do you perceive the relationship then between Biology and societal issues?

L: Well Biology enables us to understand more and more about ourselves and society as a whole. It affects us in many ways, because there are so many diseases and disorders and things that are happening in our society. Biology is a means of learning about these things and possibly changing them or doing something about them. But that's not always possible, so certain things continue to persist in our society that we really can't do too much about. But I think that if we have a good understanding of these things, it helps.

I: Alright, so you definitely see Biology as being important to what's happening in society.

L: Oh yes.

I: Could you say the same about technology? Does Biology affect the way we use technology?

L: I think it does. Just the fact that we use technology, we have to make certain adaptations and learn certain techniques to use as technology. How else would it affect us? Well . . . technology has side effects and that affects us human-wise. There are certain things out there that are causing problems in humans - pollution as an example. Probably in ways we don't know. There are a lot of unknowns. I think there will always be a lot of unknowns.

I: Alright, so you perceive an interaction between the Biologist and the theory - and the technology in our society and the ethics of our society?

L: Yes.

I: What do you think a Biologist, as a 'Scientist', does?

L: A biologist as a scientist works with limited items and materials and tries to predict, or change or control some type of thing that's happening with this particular item.

I: Alright. You mentioned 'predict, control'. What is your definition of Science?

L: Science is the ability to understand changes and happenings in our environment . . . of physical things, chemical things, biological things . . . I don't know.

I: Well, let's leave that for a moment and maybe come back to it after a few other questions. Do you think that Biologists are mostly male or female?

L: I don't know. Well, I think, well . . . probably about half and half.

I: Do you perceive your male and female students here in class, as being equally interested in Biology?

L: Yes. I think so. [Researcher's note: this is contradicted in the second interview].

I: You mentioned that Scientists are interested in understanding physical, chemical and biological items. How do you think Scientists go about understanding or 'knowing' these things?

L: Just from personal experience in different situations they are exposed to, and then by learning some of the actual facts pertaining to those situations and trying to tie everything together and coming up with some conclusions.

I: So tying the facts together to reach a conclusion about something?

L: Yes.

I: Do you think the 'Scientific method' is involved in this process?

L: Hmmmm.

I: And what is the 'Scientific method' to you?

L: Inquiry method - where you are asking questions about some particular thing. You are hypothesizing as to what you think might occur and then you do some sort of procedure at some point - get the result, interpret the results.

I: Alright, what then is objectivity?

L: Being objective - not being influenced by pre-conceived notions.

I: Do you think that Science is objective?

L: Should be. I don't know if it is or not.

I: What makes you doubt that it might not be?

L: I'm must thinking about all the things that are written in texts. From my experience, especially with this work I'm doing, all the knowledge that has been put into books. It's sort of maybe limiting us - or maybe we don't want to know if other things are occurring or if they are actually happening.

I: Do you think that's because we bring with us a set of beliefs . . . and so when we look at these things we question their validity?

L: Yes, I think that's it.

I: So what determines the 'truth' of something in Science? What is 'truth' to you?

L: There are laws that have been proven through much work and experimentation - and the results are always the same and therefore the law stands as written, because we have proven it is correct.

I: So consistency in results would be one way of determining an absolute law.

L: Yes. And therefore after a law has been proven many times over, I would say we could summarize that this is a 'true' thing that is happening . . . Well, they're similar - but I guess they're not the same. Truth and laws are not the same thing. I don't really have a definition for truth.

I: Alright. So you do think that absolutes exist?

L: Yes.

I: Do you believe in God?

L: Yes.

I: Do you think that Science helps us to define our absolutes?

L: Yes.

I: Do you think that Science can verify the 'truthfulness' of something?

L: Yes.

I: Does Science then have any limits to its own knowledge?

L: No.

I: O.K., Lillian. What or who causes change in Science?

L: Life causes change.

I: Well, do you think there is anything in the method of Science or is it the people who cause change, in Science?

L: I think it's a combination of both. This is hard!!! (laughs). I don't know.

I: O.K. I don't mean to get too abstract - don't think your answers have to be sophisticated - just give me your first impressions! If there is going to be a change in Science - let's take Biology as an example; if there's a change in a law or theory of Biology, do you think that change comes about because of the type of research the Biologist is doing - the type of equipment - or is it a new breed of Biologists who have come out with different ways of looking at problems.

L: I think more knowledge being available on certain topics - just more in depth study than we've ever dealt with . . . that's happening all the time.

I: So, learning more about topics?

L: Ya, the more we find out about certain things, the more controversy we see. Some things that we thought were always happening and now we see differently.

I: You mentioned that Biology as a Science, related to Technology and to Society. Do you think Scientists should make rules for society?

L: I don't think they should make them, but I think they should contribute to societal rules or things that we feel should be done. Because of their expertise, they can be valuable contributors.

I: Alright. Do you think that 'Scientists' are mostly male or female?

L: Male. I think that Scientists, in general, are male.

I: And do you perceive your male and female students as being equally interested in 'Science'?

L: I think so, now, but when I look at the distributions . . . well this semester I've got about 20 guys in Biology and 10 girls.

I: So there are fewer girls in your Science classes?

L: Yes.

I: Do you think that students are more or less interested in Science, now - perhaps compared to when you first started teaching?

L: I think they're about the same . . . well . . . ya . . . I think so . . . well . . .

I: Well . . . like you're not really sure . . .

L: No, I think it's about the same. I think that students are interested in Biology in my class. I think it's a course that (30, in particular) only those who are interested - take.

I: Alright. Do you perceive more girls or boys asking questions about Biology in your class?

L: I tend to get a lot of questions from the boys. I don't know why.

I: You're not sure why that would be?

L: No, but well, they tend to be less inhibited, I think. Girls are a little more conscientious - no, not conscientious - uh . . .

I: Self-conscious?

L: Yes, that's it. It seems to be that way. Boys are not as self-conscious.

I: Can you think of a reason why that might be true? - why girls, just in your own understandings and interpretations, might not be as open?

L: Yes, well I think that the girls are actually a little more mature. The boys are a little less mature.

I: So you think maybe the girls are "stopping to think before they speak?"

L: Ya, I think so. They're thinking about what's going on. Why they do ask a question - it might not be as often - but it is usually a good question. I get more nonsensical questions from the boys. I think maybe there is a difference in the maturity level.

I: Alright. What is appealing about 'Science' to you?

L: I'm not really sure.

I: You mentioned that you chose to go into Science in your undergraduate work - that you were one of the few females that went into it . . .

L: Oh yes. I liked it. It appealed to me because not as many females were doing it. I thought it was more of a challenge, to go into it, for a girl. I don't mind challenges, along the way.

I: Alright, well do you think that Scientists can be emotional or have feelings about their work?

L: I'm not sure about that.

I: Well, do you think that Biology is a more 'feeling' science than Chemistry or Physics?

L: Oh yes, I think so.

I: Do you think that those feelings or emotions should play a part in the kind of research that we do?

L: They shouldn't but I think they do . . .

I: Yes . . .

L: I think they do have factor in how decisions are made.

I: You said you think they shouldn't . . . is that because you feel Science should be objective?

L: Yes . . . I think it should be fairly objective. Yes.

I: And do you think that feelings or emotions should play a part in making societal decisions about science?

L: Again, I think no, but I think they do come into play - that's why we have certain issues that are so controversial which take feelings into play.

I: What attitudes would you most like to impart to your students about Science and secondly Biology?

L: My greatest goal is to have individuals develop a love for learning and I want to give them an interest in a particular area and hope that that interest will wear off on some of them, too. And so I want to reflect the fact that I'm interested in this particular area and I'd like them all to be interested also. Basically, I'd like to have these individuals continue in learning. It's just not an end thing. It's just not a course and that's it. I want them to go on further, on their own, at their own liking, and into whatever areas they're interested in. It's a stepping stone.

I: Alright. Is that any different from what you'd like your students to pick up on, in Biology?

L: No, not really. Just to develop a life-long interest in a particular topic.

I: Are there any differences in the way you teach Biology now, compared to when you first started?

L: Oh yes. When I first started, I basically followed a curriculum - just black and white. And I just didn't seem to have the time to go into anything else that wasn't in the curriculum. I now find that I can divert myself a little bit more - and give them more topics that are related to the core issues. It gets them more interested . . . sort of a personal diversion.

I: What determines what you add to a curriculum?

L: Probably my own personal interests . . . and questions from the students. If there are things that the students are really interested in I try to go into it a little bit more . . . or find out more about it, if I don't know enough.

I: So you like to augment your curriculum . . .

L: Not much, but a little bit.

I: Are there any parts of the curriculum that you might leave out?

L: Uh . . . I don't think so. I think it covers everything quite well.

I: So does that mean that you think the current Biology curriculum meets the needs of what you perceive Biologists would like students to know?

L: Yes, it does.

I: Just getting back to the actual teaching - are there any different methods you might use - besides the content - compared to when you first started teaching?

L: I don't think there are different methods that I'm using.

I: I noticed that you main style of teaching was to engage the students in conversation about the topic, with overlays, some board work, and then field the group for questions. Is that typically your style of teaching?

L: That's typical.

I: Do you like to engage the students in conversation - as an information source - or do you typically like to be the source of information?

L: I try to get them involved as much as I can. I try to be part of the class itself and not just a person up at the front. I try to get a pretty good grasp of what the students are doing and learning, by circulating as much as I can.

I: Alright, I guess that leads me to a question . . . I noticed that in your teaching, you quite frequently got off topic to discuss societal issues related to science, if they were raised in class. Do you feel that is important?

L: Ya, I do. I think I probably do that, when I see that individuals are interested. If there is interest in the class to discuss some type of a topic that is not part of the curriculum - but is related - I don't hesitate to spend 10 minutes, 20 minutes, half a class or even a class, on that topic.

I: Do you perceive that your style of teaching has been affected in any way, by departmental exams?

L: I don't know because I've always taught for the departmentals.

I: So as long as you've taught - there has been standardized testing.

L: Yes.

I: Do you find any time constraints or restraints of any kind because of the departmental?

L: I don't think so. I don't think it changes it much.

I: So if there were no departmental exams, you don't think that your teaching style would change that much.

L: I don't think so. I think that we'd still have to be spending about the same length of time on certain areas. Our goals would probably be about the same or at least similar.

I: So you're happy with the standards.

L: Sure. I like the fact that students take it more seriously, with a standardized exam. Otherwise I don't think they'd take the course seriously. They'd try and get by with a little less work. With the diploma exam, it's like it's someone else handling it at the end of the year, and that external person they don't know about, I think puts a little more scare in them.

I: Makes them more responsible . . .?

L: Yes, otherwise they know who's going to mark the exam; who's going to write it . . . and it doesn't seem as tough.

I: Do you have Biology 'projects', in your class?

L: Not this last term, but I always have in the previous classes I taught. It was a semestered class, as opposed to a full-year class and I had not done a semestered class before - so I didn't have a project.

I: O.K. Do you take the students on field trips . . . did you take them on any this year?

L: Not the 30's. No, uh . . . no.

I: What do you think of the new STS curriculum that's coming about. How do you feel about it, for your students?

L: Well . . . I'm not too sure yet. I'm not familiar enough with it to say if it will be positive or negative for the students. We'll have to wait and see.

I: What about yourself . . . how do you feel about the curriculum, as a teacher.

L: Oh, we have to adapt to all sorts of situations; I guess it will be fine.

I: With your General Science background do you feel prepared to handle it.

L: Oh sure, I feel O.K. with regards to content.

I: O.K. Earlier in class, you mentioned that the current chair of your Science Division is a female?

L: Yes.

I: How does she affect the grading and evaluation in your course?

L: Well, she doesn't really affect grading but she isn't a Biology person; she's a Chemistry person and she doesn't have any knowledge or training whatsoever - no courses - no interest - no knowledge.

I: Does this interfere in any way with teaching your Biology course?

L: Yes, in terms of getting lab space, materials . . . it's unfortunate. It would be nice to have a General Science person as a department head because then they're familiar with Physics, Biology and Chemistry and not limited to just the one.

I: Thanks, Lillian.

FINAL INTERVIEW: TEACHER - BRENDA

I: Researcher
B: Brenda

I: O.K. First of all, I just wanted to find out how many years of teaching experience you had . . .

B: O.K. I've had seven years at the junior high level and this is my third year senior high.

I: O.K. And what was your undergraduate background? What degrees do you have?

B: I have a B.Ed. - major in the Biological Sciences and a double minor in French and German.

I: O.K. You said you have a double minor in French and German - so that indicates you have some Art courses - in the Humanities?

B: Yes, just the Bachelor of language courses themselves - and then phonetics . . . things like that . . . one C.I. on teaching a second language - and I have some teaching experience too. I taught French 20 for a few years, too.

I: Alright. When you took your undergraduate course work, did you do any work at all in the History of Science or in the Philosophy of Science?

B: I took one course in well . . . it was sort of . . . well in the history of science . . . uh . . . it was a little bit of philosophy . . . but mainly on history . . .

I: Have you every used that? . . . Is there anything from that course that you have ever brought into your . . .

B: Just a smattering . . . like the main ones like Fleming . . . you know . . . not a lot of it

I: Alright, so individual scientists in history who might have contributed to biology . . .

B: Right.

I: Do you have any other specialized levels of training . . . even a Saint John's course?

B: I took . . . through the Faculty of Extension . . . a TESSEL course . . . teaching English as a Second Language . . . I was just sort of interested

because I had taught French, sort of as a second language - I'd done that - and now it came in handy because I have one ESL class.

I: O.K. And . . .

B: And that's not very extensive, like five Saturdays or something . . .

I: You mentioned that you have one ESL class . . . now in addition to your Biology, do you have any other language courses?

B: Well it's not a language course per se, but I do slow it down, instead of teaching Biology in a semester, I teach it in a full year . . . and they still get the 3 credits. So I don't really water it down too much . . but I slow it down. They write the same common unit exams . . .

I: Alright. So your teaching load then, is Biology . . .

B: And I've taught Chemistry - Chem. 20 -

I: As well as the French, then . . .

B: Right.

I: And did you have any other ideas about your career in teaching . . . did you want to continue teaching science . . . or did you think you'd maybe go on in Administrative work . . . or . . . go back to school . . . or any other ideas . . . or are you happy teaching!

B: For now, I'm happy teaching . . . I wouldn't mind getting eventually into some more Chemistry, maybe . . . and I suppose it wouldn't hurt to get some more physics . . . some where along the line . . . it doesn't appeal to me, but with this new curriculum coming in, you're going to have to sort of be more all around . . .

I: O.K. So your only motivation for going on and doing more course work would be to augment the sciences, to adapt to the new curriculum?

B: Yes. I have no interest whatsoever in Admin. Maybe somewhere along the line, say as a Department co-ordinator, or say take a year off and become a . . . what do you call it . . . practicum associate at the U. of A. . . . but never along the lines of Admin.

I: Alright. Do you have any other social or personal interests related to teaching science . . . in your own personal life, any hobbies?

B: Not really. Although I get involved with Science Fair and Science Olympics . . .

I: But what about personal interests . . . hobbies . . .

B: Nothing that could really be called a hobby. I go to the Space Science Centre . . . but nothing that could be called a hobby.

I: O.K. What motivated you to decide to go into Biology, when you were in undergraduate work? What made you decide to choose Biology as a profession?

B: I was always really interested in the life sciences . . . I found them really interesting . . . I started off with your basic 100 level Biology - and enjoyed it and decided to make that my major.

I: O.K. Your interest in the life sciences motivated you to go on and do a degree in Biology? What about the teaching aspect?

B: Oh . . . I don't know . . . it's just something I wanted to do for years . . .

I: So you always knew you wanted to be a teacher?

B: Ya. Although I find time constraints in teaching.

I: O.K. What about this?

B: Ya, I find there is some leeway, but I have to remain conscious of it . . . you know, I can't be finishing the Nervous System a week and a half behind everybody else . . . you know . . . I just won't finish the course.

I: O.K. Do you think that because of those time restraints its easy to discuss societal issues in the classroom . . . like if a student should instigate a question and want to spend some time on this - would that uh . . . make it difficult for you to take that time to spend with them . . . or are you always aware of that . . . or do you ignore it . . . .

B: No, there's always some time for that! It's not that you know, you just have to stay strictly with the facts, there's always time for discussion.

I: Alright. So if a student were to instigate a question that was slightly off your topic, that had to do with Biology, would you pursue it?

B: Hmmm . . . Yes.

I: I'd like to clarify what you think the difference is between Biology and the physical sciences - Chemistry and Physics.

B: Biology is a life science. I also look at it as a more active science. In the physical sciences you are just working with formulas and so on. Not that there aren't applications from that.

I: So you see the activity as important . . . less passive perhaps . . .

B: Yes, that's it.

I: Alright and I'd like to know what you think the relationship of Science - not just Biology now - but Science is to society?

B: O.K. I think the most relevant or closest relationship is the research that the science brings. For example in the medical field. And also just in terms of technology - like making machines that operate better for us and make our life easier.

I: Alright. So you see it as a positive - a constructive relationship. Do you think that there is a difference between theory and practice - what Biologists do theoretically and what they do practically?

B: I guess, depending on what kind of biologist you are. I mean there's the research biologist who does mostly theory. The practical biologist - well, what comes to mind is the wildlife biologist.

I: So would you say that a biologist could do theory or could be practical like a wildlife officer?

B: Right.

I: Do you think biologists are mostly male or female.

B: I think it's getting close but probably a little heavier on the male side.

I: And do you perceive the male and female students as equally interested in Biology?

B: Yes. Especially the ones I have this year. The breakdown is very close in Biology 30 and overall in Biology, there are more girls.

I: Do you think that more females go into Biology than into the Physical sciences?

B: Yes.

I: Alright. Can you think of a reason for that.

B: I think that they have been geared that way. Males are encouraged to be more Math oriented and to take the Chemistry and Physics, because of the careers that they are going to pursue afterwards. And well, females they become nurses, so they take Biology. But I think that's changing and females are pursuing all kinds of careers . . . especially like with the WISEST conference and from certain posters I've seen: 'I want to be an engineer like my Mom.' And things like that.

I: Are you participating with WISEST in selecting high school girls . . .

B: Uh, well I've been active in giving a reference for girls who want a reference for the summer work and I advertise the conference. But I've never been actually part of the conference.

I: So you see the relationship between interest in the subject matter as correlating with the type of career that the student will pursue . . .

B: I think so.

I: Do you think that there is a natural interest women have in Biology? Or is it a cultural interest . . . or what?

B: Oh, that's a tough one. I don't know.

I: What made you pursue Biology as a subject matter?

B: The life sciences sounded very interesting. I wanted to teach. I wanted a job where I would be dealing with people. I thought it would be an interesting subject to teach. Especially Biology 30 - the human physiology.

I: O.K. Why Biology 30?

B: It relates to how the body functions. And I like Genetics.

I: Do you have any children, Brenda?

B: I will at the end of October!

I: Oh really! How wonderful! Is this your first time around?

B: Yes.

I: Do you find Biology more relevant now as you anticipate your unborn child?

B: Absolutely! I have more relevant facts floating around in the Reproduction unit because I'm doing more reading.

I: When you were in College, how did you find taking Chemistry?

B: Negative. I found the course tougher and I didn't know why. The material seemed more difficult. Biology seemed more relevant.

I: Relevant to what?

B: To me, personally. Although organic I can see it as a stepping stone to understanding biological things better.

I: Alright. If I were to ask you what you thought Science was, what would you say?

B: Science is about things around you. Understanding how things are put together. The word research comes to mind, uh . . .

I: When you say research, what kinds of things come to your mind. What kinds of things do scientists do in research?

B: Scientific method - problem solving.

I: O.K. What is the scientific method to you.

B: Oh, it's identifying a problem, hypothesizing, analysing the data and verifying the hypothesis.

I: You rattled that off well [laughter]. Do you think that this leads scientists to their understandings - their knowledge?

B: Yes, usually they have someone else's work to go on and then they just try and modify that or extend that. You have to have some sort of knowledge first. And looking at that given knowledge, it may trigger a new idea in their minds where they might pursue a new question.

I: Alright. Do you think that the knowledge that the scientists have is in any way personal knowledge or is it just 'objective' knowledge?

B: Probably a bit of both. I think the real issue is funding. Take for example cancer research. If someone really wanted to pursue that because of financial interests . . . I don't know . . . I was in the lineup at Safeway once listening to a grad student researching the liver of a spider - gee I didn't know spiders had livers, but obviously there is no big financial push there - it's just a personal interest.

I: O.K. What does being objective mean?

B: Well, it means rational - not letting your personal views interfere . . . basing your decisions and opinions on the facts.

I: Do you think most scientists are objective in the way they go about doing their work?

B: Yes.

I: Do you feel that you present your material in class, to students, in an objective fashion?

B: Yes, but some topics I know that I'm very subjective. But then I tell them that I am. I have just done the Reproduction unit and my view just surfaced automatically when I'm talking about different forms of birth control and abortion.

I: When you talk about ethical issues related to birth control and reproduction in the classroom, does that bother you at all? 'Being subjective?'

B: No, but I do try to make the point that this is my opinion, but there is the opposite side that people might argue too.

I: Hmmmm. Do you think that absolutes exist?

B: Yes.

I: Do you believe in God?

B: Yes.

I: Do you think that Science helps us to define absolutes?

B: Yes when defining physical laws and all that stuff.

I: Do you think that laws and theories are the same things as 'truths'?

B: Well, yes . . . laws . . . but then there are theories . . . like the theory of evolution . . . there are facts which point to supporting theories and facts which disprove them.

I: O.K. In order to prove something to be true - you would find out whether the facts are consistent?

B: Yes, verification.

I: Alright. If there are changes in Science what or who causes change?

B: Oh I guess the scientists doing the research does. Oh, new discoveries, maybe like in Astronomy - they talk about certain planets and how many moons they have and then when they send out satellites and they discover new moons and rings. Or some diseases have been around for decades but they have just never isolated the virus.

I: Alright. Do you think that the sophistication of our technological equipment assists us . . .

B: Oh yes.

I: Do you think that science has limits?

B: Yes, because scientists are human.

I: Do you think that scientists should help society make decisions about which problems to investigate?

B: Yes. I don't know if they should be active in the decision-making process - well they influence the decisions being made. Like this genetic engineering - society tends to limit that and decide what is acceptable and not acceptable.

I: So society does put limits on what are acceptable problems for investigation?

B: Yes. Scientists are just the experts to rely on for information and advice.

I: Do you think that biology is more human or 'feeling' science than physics or chemistry?

B: Yes, definitely.

I: Do you think that emotions or feelings should be a part of decisions we make about which problems to pursue in Science?

B: Yes. Although sometimes I think that if they interfere too much they might block 'good' decisions. But because you are dealing with living things it has to come into play.

I: When you say block 'good' decisions - can you give me an example?

B: With things like genetic engineering . . . I don't think they can pursue things to the extent that they technically could . . . because they're afraid . . . [long pause]

I: Yes? [Wait]. Well, if you're worried about the moral views about this kind of knowledge - then do you think morals and ethics are important in making decisions about what kind of research to do?

B: Yes. I think so. But the scientists who are doing the research would probably say no because you are letting your feelings get in the way. Maybe you are preventing us from discovering something.

I: So you see a difference between the way you perceive the place of ethics in scientific research and the way an actual scientist might perceive it?

B: Yes. I associate scientists with complete objectivity, really.

I: I see. What attitudes would you most like to impart to your students about Science?

B: I'd hope that they'd just develop an interest in it and know that it's something that they can do life-long. You know, go on and take courses at the University. Read the sections in the journal about biomedical research and things like that. And not take for granted how much it influences our life.

I: How about Biology?

B: The same. Students realizing how they can integrate it into their lives.

I: Do you think most Scientists are male or female?

B: I think its more heavy on the male side. But I think that's still the older generation. I would guess from the newer generation that it is becoming equal.

I: I see. Do you see this as a result of equal opportunities for boys and girls in school?

B: Yes. Women's roles are changing.

I: If I were to ask you the attitudes of the male and female students in your class, do you find the female students are as interested as the boys in biology?

B: Yes.

I: Are the girls as interested as the boys in Science?

B: Uh . . . I think they are getting to be more so . . . you're starting to see more girls in Science.

I: I noticed in one of your lectures, you talked about a lab you were going to do - a dissection. The girls were expressing disgust and the boys were saying - Oh fun! Is that typical in the actual lab?

B: No. Once they get into the lab they're the ones who do the work. I think the girls just do that for effect on the boys. Except for the Grade 10's - the girls are squeamish. But I just tell them, Well . . . you're taking Biology and you know what's involved in the course. If you don't like it . . . take physics.

I: Do you think girls are playing roles - peer roles, when the Grade 10 girls act like that?

B: Oh yes. They're expected to be squeamish.

I: What about the kinds of questions that girls ask in your class? Are they different from the ones that boys ask, in Biology?

B: No. It varies more on ability. The higher academic kids ask more questions. They ask a question because they want a 92 on the unit exam.

I: Are students more interested in Science, today?

B: Yes, I think so.

I: Do you think that it is in any way related to having to pursue a career? You mentioned the student who wanted the 92% asked more questions. Would you like to expand on this?

B: Hmmm. Yes. I think these students would probably ask as many questions in Math 30, Chem. 30, etc. Certainly drive has something to do with it . . . in our society.

I: Are there differences in the way you teach Biology now as compared to when you first started?

B: Yes. I was more factually oriented. Less open to discussion. And now I know my time restraints.

I: Would you take the time then to . . .

B: Yes I would engage in a class discussion. Also I know my content better, now. Kids always ask questions you know. And if I don't know I say I will find out for them. And usually this is knowledge that I can use again to help another kid or add to a unit.

I: So, in part student interests are shaping your curriculum?

B: Hmmm . . . well, in part. But there's always that curriculum dictated by the departmental exam which you have to get through.

I: So does the diploma exam dictate the curricular knowledge you teach your students?

B: Absolutely. What is extra . . . is of interest mostly to me and also if students ask.

I: Do you think that the Biology curriculum is meeting the needs of what students should be taught in Science?

B: At the 30 level - yes. At the lower levels, well . . . they just make them go through so much with all the different phyla and stuff. It seems like you're just cranking out the stuff. I would like to see less information. And do science better.

I: Do you leave parts out of the curriculum?

B: No, but sometimes I add and select according to my interests and kids interests.

I: Does the current Science Division Chair in any way affect how you teach Biology?

B: Well, no . . . the two obligatory visits I get every year for evaluation . . . well they really don't know what's going on anyway. They are more concerned with the outcome . . . how many honours on the departmental . . . but then they're getting that pushed on them too from higher up. You know I get very concerned if students are learning everything. I have been taking this teacher effectiveness programme, but unfortunately there is not a way to ensure every kid is learning. That's because they are too many kids. You start out in Biology 10 with a ceiling - 35 students . . . how can I deal with each student and all my other classes?

I: Yes. I see. You mentioned you get very concerned if students are learning everything. Do you feel you have to 'take charge' in a classroom, in the sense that you wouldn't like anyone to be teaching (substituting) your classes for you? You seem very conscientious . . .

B: Oh yes. Like one day on a Friday I dragged myself into school when I was ill and stayed long after everyone had left. I wrote up plans for my substitute on Monday because I didn't want to have to pick up pieces when I got back. I also give tutorials after class - informal ones. But usually only four kids will show up and they're all the good ones.

I: Do you have Biology projects?

B: With the 20's. But there is no time in the 30 level.

I: How do you feel about the new STS curriculum, do you feel it would be a positive or negative change, for your students?

B: Well, from what I've seen of the Chemistry . . . like when I taught it . . . I taught the old one - ALCHEM - just from what I've heard from a few people around me teaching it now, ummmm . . . they say that in some units they go overboard on the part of it . . . on the implications for society. There's little readings and stuff they have to do and they say sometimes there is just too much of that kind of stuff . . . but then again, they're coming from the ALCHEM, too, which was quite a different approach.

I: Now disregarding how THEY feel about it, how do YOU feel about that - do you think that you can do too much in the area of science and society . . .

B: Yes, I think you need to include that definitely, as part of your course . . . your science course, but ya, you can get too much into that and not enough into the scientific facts . . .

I: In other words, theory and facts are important in teaching about science . . .

B: Yes, you shouldn't neglect the societal types of things, altogether, but I think there should be a limit on that part of it . . .

I: Alright. How about the effect on the teachers . . . let's stay with YOU, because it's hard to say how other teachers will react . . . how do you think it's going to affect you?

B: I think it's harder to teach that kind of thing . . . I mean, I don't shy away from it totally - like I already have part of that sort of thing in my courses now, but I definitely think it's more difficult to teach that sort of thing, than the fact part of it. Teachers that aren't informed about certain areas are going to have to get more informed; I think too that they can have more of discussion on things. Especially like if it were a weaker area . . . like for instance, myself in Biology I can expand on things much more readily than I could in a Chemistry class . . . because my own background is much stronger.

I: So you're a little concerned about the actual content and maybe the possibility of it being watered down, in the schools, because teachers aren't up on the content the way the curriculum might dictate they should be?

B: Yes. I also don't like the shift that seems to be coming, where there will be a lot of what I call General Science courses . . . that you would have to teach like a Biology and a Chemistry and a Physics type of segment in that course . . . I prefer them the way we have them now. Maybe once we've tried the multi-course thing, I would prefer it, but . . .

I: Is that in any way related to the way Science is done at the University level . . . being specialized?

B: I suppose . . . but I'm more or less specialized too; I mean, that's where I have more courses and more interest too. I think interest has a lot to do with it. If you're not interested in the course you're not going to be that motivated to find out all those extra issues to bring into your classroom.

I: Well thank you very much, Brenda.

APPENDIX F

VALIDATION OF TRANSCRIPTS AND DATA

VALIDATION OF TRANSCRIPTS AND DATA: TEACHER - LILLIAN

WHAT IS THE THEME AROUND WHICH THE TEACHING TAKES PLACE?

- I observed that the basic themes for your unit on Excretion, were based on curriculum requisites, exactly as written in the Curriculum Guide by Alta. Ed. (1984). This guided the course of the topics you chose to present to the students. The Curriculum Guide further suggested that ethical issues could be raised in connection with kidney transplants, as well as further discussions extended to infections or medical disorders associated with kidney malfunction (dialysis); the latter of which you chose to discuss in class. You also elected to discuss the effects of alcohol on kidney function and homeostatic mechanisms the body uses to adjust to water loss.

- I perceived that you presented the unit as a collection of specific informational statements translated to the student: the basis upon which information was accepted or rejected was empirical - that is, the knowledge had been experimentally verified.

- I observed that the authority for your knowledge presentation was based on your text-book; on curriculum dictates; and on potential departmental questions which would reflect specific informational components.

WHAT IS THE PREVALENT MODE OF TEACHING THAT OCCURS IN THE CLASSROOM?

- I noticed that you spent very little time actually giving notes; rather you preferred a conversational style where students engaged in discourse with you. Much of the factual unit information presented to the students was guided, by you in a 'directed-inquiry' fashion. You seemed to direct questions to the students - fashioning their responses according to your knowledge of your topic.

- I also noticed that you often prompted students' responses with reference to potential departmental questions; you also mentioned in your interview that the departmental was indeed a good idea: "I like the fact that students take it more seriously with a standardized exam, otherwise I don't think they'd take the course seriously." Overall, I got the impression that you wanted your students to know that your topic was important because the departmental exam was important.

Challenge to Authority:

- I also noticed that out of your total teaching time, about a fifth of it was spent on management disruption. In particular, a group of boys in the far left corner and Student (s), were consistent instigators. I noticed that they often asked you irrelevant questions, off topic, and challenged your responses. In each day's lessons, there are frequent examples; here is one:

L: "Our red blood cells are too large to get forced through the walls . . . therefore urine is NOT red."
(s): "But sometimes, urine IS red!"
L: "Yes, if you have an injury . . . red blood cells can get through."
(s): "What if you eat ketchup?"
L: "No, Student (s), but if you eat beets . . .!"

- I noticed that you often redirected Student (s)'s thoughts and actions by using humour . . . or involving other class members into the discussion, to dilute his intensity.

- I noticed that it was not necessary for you to always be 'authoritarian' and that you frequently used humour to dispel student conflict.

- You also have a very modern, casual, yet personal style which I perceived students liked, and which you use to let students know you are human and can relate to them.

INTEREST IN THE COMMUNICATION PROCESS

- I noticed that in your interview you discussed the influence of your husband's career on your own and felt strongly about personal health-related issues guiding both your personal and professional life. I noticed you brought this into class, when you chose to discuss AIDS, one day. You gave very personal insights into the topic, and allowed for student comment and response.

- I noticed that it doesn't bother you to get off topic. In fact a fourth of your class time was spent, off topic. You mentioned in your interview that if students were interested in topics, other than what was on the agenda for that day, you would not hesitate to pursue these interests.

- I noticed that you mentioned that more boys than girls, were interest in SCIENCE, in your interview. You also mentioned that you felt this was in part because girls were more self-conscious and probably more mature. In class, you directed more questions to boys and more boys responded to your own instigated questions. More boys also initiated questions, to you. You mentioned you chose Science, because fewer women entered the field and you enjoyed challenges.

- I noticed you questioned a male student for having a female student take notes for him; you also questioned the girl involved: was she his 'secretary'? I also noticed that your female students responded more squeamishly, to a potential description of a kidney dissection, than your male students.

- In the interview you mentioned that you would like students to enjoy 'learning' and that this was just a stepping-stone to future interests in Science (Biology). However you do mentioned that students won't take things "seriously", without a departmental exam at the end . . . there is some ambiguity, here.

WHAT CONSTITUTES BIOLOGY AS AN AREA OF STUDY

THE RATIONALE FOR TEACHER'S UNDERSTANDING

- I perceived your understanding of Biology as being concerned with anything and everything about 'living things'. I perceived that your own personal philosophy was based on an understanding of a natural world that exists in reality and that your perceptions of that world come through sense experience. This is further defined as empirical: the scientific method is seen as the process through which natural characteristics are established as knowledge. This is how you have thought through what you have been taught about Science.

- You perceived scientific laws and facts to be true when they can be verified through experimentation, however you are not sure if a law is the same thing as 'truth'. When pressed you weren't sure what 'truth' was.

- There is a 'personal' knowledge that you have incorporated into your understanding - based on you 'intuitive' feeling or personal feelings that you have about your health and your parents loss of health. You are ambiguous about whether 'feelings' should play a role in societal decisions about Science; you say you think they shouldn't but are not sure.

- You often bring societal issues and student's concerns of these issues into your own class discussions. You often state your own opinion . . . which is based on your values and health-conscious philosophy.

L: "If you know better, understand the facts, live healthy . . . you won't get AIDS."

L: "How about abstaining from sex until you are married?"

Student: "That's old-fashioned!"

L: "That may be old-fashioned but it would sure cut down on AIDS!"

- You feel projects are important in teaching Biology, however you admit that time constraints, especially in semesterized teaching, limits this possibility. You did not have a project this year.

- You suggested that lack of understanding on the part of the Division chairperson led you to cut-down on lab-work, because it was erratically and carelessly timed and prepped. Your students picked up your concern, when you engaged in the Aerobics lab. You were moved to a different room (Chem, instead of Bio.) and had to put up with fumes. You mentioned your displeasure and students complained about equipment set-up. Students however, were made to wear plastic white aprons and you checked to make sure everyone had them tied up.

- You made the statement to your class: "When you draw a conclusion, you have to have knowledge and we're a little limited in our knowledge, right now." I would like to fit this into your understanding of knowledge as defined by Science.

- You mentioned: "I'm just thinking about all the things that are written in texts. From my experience, especially with this work I'm doing (work with Ukrainian text analysis) all the knowledge that has been put into books. It's sort of maybe limiting us - or maybe we don't want to know if other things are occurring or if they are actually happening." I would like to fit this into your understanding and knowledge as defined by Science.

- You mentioned one of the reasons you changed from Physics to Biology was because of the professors . . . you couldn't understand the Physics prof., but found the Genetics prof. to be very human - he related information about Biology to you in a personal manner (you were pregnant at the time). This influenced your choice of subject matter . . . Biology to your potential child.

VALIDATION OF TRANSCRIPTS AND DATA: TEACHER - BRENDA

WHAT IS THE THEME AROUND WHICH TEACHING TAKES PLACE

- I observed that your basic themes for the unit on the Circulatory System - of which I observed the section on 'Heart and Blood Vessels' - were based on curriculum requisites, exactly as written in the Curriculum Guide by Alta. Ed. (1984). This guided the course of the topics you chose to present to the students. Suggested elective topics, according to the Curriculum Guide, including 'technological developments of heart and lung machines', developed to facilitate circulation; and discussions of current medical surgical technology to facilitate circulatory function, i.e., pacemakers. You chose to discuss all of these elective suggestions, in your class. Your knowledge was up-to-date and you augmented lecture material with medical applications. For example, you read the class an article on artificial hearts from *Science World* and you stated:

> I attended a symposium at the Convention Centre, on current information on blood and circulation. This is hosted by the Red Cross Association. I saw the computer model, used at the U. of A., to train medical students on heart attacks. It was fascinating. I asked my students to attend, but no one did . . . I applied what I learned from this and used it in my notes and lecture material.

- Your notes are clearly and effectively organized, divided into sub-headings, and the level of detail is slightly above what curriculum mandates require. I perceived that you presented the unit as a collection of specific informational facts translated to the student.

- You augment your lecture material from the textbook, the outside conferences you attend, science magazine articles and other first year University textual material. The above sources, are the authority for your knowledge presentation. You are also guided by departmental standardized exam content. You stated, in a section on systemic circulation: "Now, we could spend more time on this, but I'm not giving you too much, because the departmental never asks too many questions on this, so there is no use memorizing a lot of terms."

WHAT IS THE PREVALENT MODE OF TEACHING THAT OCCURS IN THE CLASSROOM?

- I observed that your teaching involved a direct lecture, 'note-giving' style. You presented a section of information, in overhead note form, explained it to the students - statement by statement, and then allowed the students time, to copy the notes down. This was usually a five to 10 minute period, depending on the length of the notes being given, and very little was said during this time by either you or the students. Students spent this time, copying down your notes. You seldom deviated from this style.

- You mentioned that there would be one section on 'Blood', where students would do their own research and write up their own notes. You stated, "I'll give you the information you need to research. I'll highlight the key ideas you need to know and then, you'll appreciate my note-giving!" The basis upon which information is accepted or rejected is empirical, that is, the knowledge is experimentally verified. The authority for presenting knowledge, I perceive, is based upon potential departmental questions and curriculum requisites.

- There is very little challenge to your knowledge presentation, by students. There are very few student-instigated questions, the few that were asked, over the unit (15), were clarification questions and were mostly instigated by males, (11/15) in your class. You directed very few questions, to students, however the few (22), that were directed to students in your class, were related to overhead note-giving and/or classroom instructions with regards to dates, format, and evaluation of labs, exams or quizzes. Answers to your questions were fashioned by you, according to your knowledge of the subject matter.

- There was very little management disruption in your class (39 min.). The few minutes indicated, occurred at the end of your classes, and your comments were designed to bring students back on task, copying notes, instead of talking amongst themselves.

INTEREST IN THE COMMUNICATION PROCESS

- I perceived your interest in the communication process, to be based upon your personal commitment and interest to and in the Biological Sciences. You mentioned in your original intents to pursue Biology as an undergraduate, that, "I found the social interaction important and I was also interested in human physiology . . . It [Biology, rather than Physics], related better to me as a person." You also mentioned that you wanted to impart to your students an INTEREST in Biology.

- I perceive an ambivalence, here, however, with regards to the presentation style of your course material. You present the unit material as a collection of facts, empirically verified and state, "Some subjects are more subjective, but I always tell students if I'm giving an opinion." You are concerned about presenting the content as empirically verifiable, and want your students to distinguish between opinion and 'truth' - as Science seeks to discover, in forms of 'laws'.

- You rely on departmental standards to guide your content material, however, you indicate that you think societal issues are important in relation to Science and should be discussed in the classroom. There is some ambivalence here again. You state: "I think morals and ethics are important in doing research but scientists wouldn't think so."

- You state that you think more boys [than girls], are interested in Science, although it is getting "closer". You perceive boys and girls equally interested in Biology and that overall your Biology courses usually contain more girls. Of the number of student-instigated questions, (15), more were asked by boys in the class (11). You directed more questions to the boys than the girls in your class (17). You stated that you felt more women to into Biology than the Physical Sciences, "because they've been geared that way . . . because of the careers that they're going to pursue afterwards." However, you state that society is changing and believe this will change. You are aware of WISEST and their attempts to bring more girls into the Sciences.

WHAT CONSTITUTES BIOLOGY AS AN AREA OF STUDY

RATIONALE FOR THE TEACHER'S UNDERSTANDING

- I perceive your understanding of Biology to be a "life science . . . more active than the physical sciences . . . with more application to things . . ." You indicate that it is a more relevant science to the understanding of human things and were drawn to it, personally, through its human applications. Your personal interests and world view incorporates Biology - the 'knowing and understanding' of living things. This personal understanding is incorporated into the way you augment lecture material and discuss medical applications of technology, in the classroom.

- The knowledge base for your understanding of Biology comes from an empirical 'knowing'. There is order to the Universe' there are absolutes, and lesson materials are presented in a very orderly, logical sequential pattern which reflects the orderliness with which you perceive Scientists engaging in their own research. You state that "objectivity - presenting facts, is a very important part of science" . . . and that although Science can't always prove theories as truths, for e.g., Evolution - the verification process that Scientists engage in, is significant. We 'discover' Biological laws that already exist, and change in Science comes about from new innovations in technology which allow new discoveries.

- You presented two labs in your unit: one on mammalian heart dissection and one on blood pressure and heart sounds, although the latter you decided to omit because of old equipment. You prefer to present material to your class in a 'controlled' fashion, whether lecture or lab, through the use of organized handouts and notes.

- You are concerned about the new STS curriculum: "I think it's harder to teach that kind of thing [effects of Science on Society] . . . I mean, I don't shy away from it totally - like I already have part of that sort of thing in my courses now but I definitely think it's more difficult to teach that sort of thing, than the fact part." You also state a concern for a multi-course, general approach . . . you prefer an ordered, specialized approach, with regards to course content.

- I sense a conflict underlying a personal philosophy which 'personalizes Biology' - makes it interesting - discusses moral and ethical issues AND an empirical approach which verifies factual information according to the scientific method and does not rely on opinion. The latter is the general manner in which your subject content is presented.

APPENDIX G

SECOND VALIDATION OF TRANSCRIPTS AND DATA

SECOND VALIDATION OF TRANSCRIPTS AND DATA: TEACHER - LILLIAN

My Comments - Bold Letters
Lillian's comments - not bold

COMMENTS TO OBSERVATIONS AND INTERPRETATIONS:

- on: **Why dept, exams are important to her:** "Students respond more to a departmental exam . . . the external factor is important. It's the objectivity factor - students can't gauge, you know, they must know the stuff" . . . "Also, Grade 12's are gearing to post-secondary requirements . . . the reality is that they have to deal with them (exams)".

- on: **Challenge to her authority in the classroom:** "I think humour is the spice of life and I like to humour them.

on: **Authoritarianism:** "I like to be friendly but firm . . . **(Her 'firmness' was never documented in the unit I observed)** being authoritarian isn't important to me. I reflect my Dad's characteristics, you know; he had a great sense of humour."

Do you think your male colleagues are more authoritarian in the classroom? "Yes".

Why? "I'm not sure."

When pressed on this, Lillian could not give a reason for her passivity, in the classroom.

- on: **personal gender influencing professional practice:** "I've always preferred to be around men. I grew up with sisters and now I'm married to a medical practitioner and we have sons. I prefer that . . . I think that way, now . . . I know that I ask more boys questions, now. I don't know why. Well, boys have more interest in academic things. My interest in Science started with an interest in things that boys were interested in . . . they had higher goals. They were always more interesting than girl's things, boys were not as temperamental . . . "

I pressed her on this issue: why 'perceived men's 'interests' seemed more interesting to her . . . and that this was reflected in her teaching (more boys asked questions than girls . . .)

We ended up agreeing this was probably in the realm of a psychoanalytic discussion . . . she had personal (childhood) reasons for this attraction - it was related to where she perceived the 'power' to be - 'with men'.

- on: **conflict between male/female ways of teaching Science/how she would like to teach Science:**

"I feel people will judge me if I bring my personal life style into it . . . I don't want to . . . but students find out anyway and they're interested. But I like to keep my distance, you know . . ."

I pressed her on this issue: there was an obvious conflict here, between what she felt appeared professional and what she would like to do. I suggested that, in fact, she often talked about other issues in class and didn't seem to keep a distance.

"I have flashes, you know, sometimes, feeling unprofessional, but then, I think, when I see student's benefitting from the course . . . . I benefit from it . . . **(Identification of *them* with *me*).**

"I would put in interesting health-related issues, if I could. 'Side-issues', you know to motivate them! I would like to zero in on topics relevant to them and their life and living in harmony . . . healthy . . ."

"But because of diploma exams, nothing like that could be tested . . . so I hesitate . . .!"

- on: **stereotypes in dissection:** "Well, you know, it's just a peer thing . . . reacting unthinking . . . as soon as they get into the job, its just the opposite! Big 200 lb. macho jocks can't handle it and the gals think it's interesting!

"Yes, I think the aprons are important . . . it shows them they should be neat and clean . . ."

Did you ever think of them as an extension of 'control or order' . . . are we trying to get a message across to students in Science? . . .

"Oh no, I never thought of that. I just thought they were clean . . . you know, in case of spills . . ."

- on: **knowledge: Who controls knowledge, Lillian.**

"I think the students do."

Do you define the knowledge for them, Lillian. through the departmental requisites . . . through curriculum . . . through what and how you teach in class?

"No, You can't make a horse drink. The students control it. Teachers are external factors. Everything students learn is related to their own knowledge and background . . ."

Is knowledge, then, contextual, Lillian?

"Yes, you've hit it right on the head. I think that I teach is contextual to my interests . . . what you have described to me is right . . . and students are the same . . . I think."